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PROGRESS IN PETROLEUM[1]

By Dr. GUSTAV EGLOFF

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CRUDE petroleums range from almost pure gasoline to solid asphalt as produced in the oil fields of the world. They have odors ranging from the rose and musk to a vileness greater than the skunk. Their colors when viewed in transmitted light vary from cherry, amber, yellow, green and reddish-brown to dense black, and under reflected light some crudes are highly fluorescent. Crude oils are composed of paraffinic, olefinic, naphthenic and aromatic hydrocarbons. Many crudes contain sulfur in combination with the hydrocarbons—in amounts from traces to more than six per cent.—while nitrogen and oxygen varies from 0.1 to more than one per cent. Traces of metals such as platinum, gold, silver, uranium, vanadium and titanium have been found in some crude oils. A few Rumanian crude oils are highly radioactive.

Crude oils are literally a wonder source of substances that are the foundation stone of a number of industries with many more to come. Their effect ramifies throughout our social and economic life and they will be a controlling factor in ultimate victory in a world aflame.

A forward-looking group of executives, chemists, physicists, engineers, and a host of other professions have made the oil industry what it is—a $14,000,000,000 organization in the United States. An amazing amount of research is going on in every branch of the industry at an expenditure of over $100,000,000 a year in order to discover and transport crude oil to refining centers for conversion into products useful to man.

The oil industry is doing everything possible to locate

[1] Address on the occasion of the presentation of the Medal Award of the American Institute of Chemists at its eighteenth annual meeting, Atlantic City, N. J., May 18, 1940.

and conserve crude oil by calling upon the best scientific and technical knowledge available. Enormous savings have been brought about by the use of geophysics and chemistry, and deeper and directionalized drilling. The Pacific Ocean bed has been drilled from the shore and oil produced. Some lakes in Louisiana and the Gulf of Mexico yield large quantities of crude.

Many of the 360,000 oil wells in operation in the United States were drilled in recent years, but substantial production still comes from wells brought in more than fifty years ago in the original oil state, Pennsylvania. Continued production from these old wells has been brought about by improved methods of oil recovery by so-called repressuring. Water is injected through auxiliary wells surrounding the oil well in order to build a hydrostatic pressure in the oil sand. This water flooding process has increased oil production in the famous Bradford field which was discovered in 1875. Production in this field dropped to its lowest point in 1900, when it was considered almost exhausted. Since then, by the use of water flooding, production has been increased eleven-fold above that of the low.

"Water-flooding, scientifically controlled so that no damage is caused in the oil formation, is one of several secondary recovery methods developed by the oil industry to increase production from oil sands which apparently are depleted. This method recently was legalized in Ohio, and already has been introduced successfully in one of that state's older fields. Gas injection, and air injection, similarly designed to build up pressures in underground oil formations and increase recovery, also have made startling advances in recent years."

As the bit bites its way toward the nether regions, water layers or heaving shales are encountered which are sealed off by chemical means. To control oil well pressures, some above 2,000 pounds, and to prevent the well from blowing out, hurtling the tools, casings, etc., a thousand feet or so in the air, counteracting columns of colloidal muds are used, which allow the well to produce oil quietly under controlled pressure due to the weight of the mud-counter to the oil well pressure.

Some years ago in Texas a huge well came in, ripping a crater into the earth and resulting in a terrific fire. There were no methods known of fighting this type of fire. For years the oil industry had been cursed by drilling crooked holes which was inevitable at that period. At times these holes ran parallel to the ground and in some instances actually made a U-bend with the other end of the pipe coming up about a thousand feet from the derrick floor. One of the engineers suggested purposely drilling a slanting hole so that the bit would enter the oil sand. Water was then pumped into the sand, shutting off the fire.

This directionalized drilling was highly successful. Wells may now be drilled in any direction, by a number of ingenious physical and chemical methods. As many as eight wells have been drilled from a single derrick floor in different directions and levels to study the geology and composition of the earth. The deepest well drilled so far is about three miles. It is certain that wells will be drilled and oil found at depths of five miles or more.

In 1860, one year after the Drake well was brought in at a 69-foot level, an oil shortage was predicted as the prevailing rate of oil consumption would exhaust the supply in a few years. This prediction has been reiterated at about five-year intervals ever since. In 1860 the U. S. A. crude oil production was 500,000 barrels and 1,250,000,000 barrels in 1939. Moreover, crude oil reserves of to-day in the known oil fields are about 20,000,000,000 barrels. During the last year alone, approximately 2,000,000,000 barrels of crude were added to our oil reserves above that actually used. Through the years crude oil reserves have been increasing by finding new oil fields, by deeper drilling in old fields, and by hydrochloric acid treatment, called acidizing, of old and new oil sands.

One of the greatest forces for conservation and well being of our social and economic life is the cracking process developed by chemists and engineers of the oil industry. This process has more than doubled the yield of motor fuel from a barrel of oil with anti-knock quality which gives over 40 per cent. more miles per gallon than Nature's gasoline. Since 1913 when the first commercial cracking plant was used to the present time, a saving of over 13,000,000,000 barrels of crude oil has been brought about. Last year alone, 1,400,000,000 barrels of crude oil were conserved by the use of the cracking units in the United States which cost $450,000,000. In short, the oil industry would have had to refine 2,638,000,000 barrels of crude to produce the volume of gasoline necessary to operate the 31,000,000 cars instead of the 1,238,000,000 barrels actually refined.

There is an ever recurrent cry that crude oil is an irreplaceable asset. However, there is evidence to contradict this view. I believe that petroleum is being formed in the earth at a greater rate than we are consuming it. So far as we know, Nature may still be going ahead with the same biochemical changes, the same heat, pressure, and time processes by which crude oil was made in the beginning at least in part. Investigations have brought to light facts regarding earth processes which from their very nature lead me to the belief that oil is continually being formed, although they have not been sufficiently established to confirm it positively.

The theory of continual petroleum formation is supported by the fact that oceans, lakes and rivers of to-day abound with fish and mollusks closely resembling those found in many petroleum-bearing formations.

Microscopic creatures, such as foraminifera, radiolaria, and diatoms, are present which are identical in body structure with fossils found in the Monterey shale and other oil-producing structures, notably in the Lompoc and Santa Maria fields of California.

Such diatoms, scooped alive from the ocean to-day, yield about two per cent. of oil by ether extraction, altough they contain about sixteen per cent. organic material. The possibility that this oil yield may be greatly increased under the temperature, time and pressure conditions prevailing in the earth, has been considered. It is also likely that some substances such as the silica body structure of the microscopic corpses in the earth exert a catalytic influence which would accelerate oil formation.

Yielding two per cent. of oil, the diatoms in the Monterey shale (which constitutes a bed 800 square miles in extent and half a mile thick in one section of California) would produce two billion barrels of oil. Present-day sedimentation of organic matter is occurring in closed basins of the Continental shelf particularly along the western coast of California. In other oceans and in the deeper waters along the coast, diatoms are depositing with organic content constantly increasing.

From the foregoing we may conclude that Nature is producing oil at a faster rate than gas pressure or pump strokes can bring it to the earth's surface. As a matter of interest, since the foundation of the oil industry, the entire world's production of crude oil would not fill a hole a cubic mile in the earth. This is an insignificant volume compared to what nature must have produced and still is producing during the years of her workmanship.

In view of the increasing volumes of crude oil reserves, the probability of continuous crude oil formation, better utilization of crude oil and its products, and considering the trifling volume of petroleum used to date, one can look with assurance as to the future oil supplies for our every need for thousands of years.

Gasoline distilled at atmospheric pressure from crude oil does not contain the hydrocarbon molecules of the type most useful to man. Some gasolines which nature produced have octane ratings as low as 15, and are worthless as motor fuels in modern cars due to high knocking characteristics. The crude oils and their gasoline content have to be converted into more useful products by thermal or catalytic cracking, polymerization, alkylation, aromatization, hydrogenation and dehydrogenation.

The primary function of cracking is to produce high anti-knock gasoline. As a by-product of this operation, the oil industry has developed motor fuels of 100 and higher octane ratings which make possible greater motor efficiencies whether in airplane or motor car engines.

The automobile industry during its early years gave indications of exceeding the capacity of the oil industry to supply gasoline. This thought spurred technical men to invent means for increasing the yield of gasoline from crude oil. The cracking process not alone provided the means for more than doubling the yield of gasoline, *i.e.,* 21 per cent. to 45 per cent. of the crude oil, but in addition improved the anti-knock properties of the gasoline.

In the past twenty years the number of motor vehicles has increased from about 9,000,000 to more than 31,000,000, while the motor fuel consumption increased annually from 109,000,000 barrels to over 566,000,000 barrels. In addition, the average motor compression ratio increased from 4 to 6.4. This is of tremendous significance from an economic standpoint in that motor efficiencies have increased more than 40 per cent. during this period.

Transportation speeds in the air and on the road have more than doubled which is primarily due to the correspondingly improved anti-knock value of the gasoline and better motor design. Pursuit planes of our Army and Navy powered by 100 octane fuel have speeds of over 400 miles per hour.

About twenty-seven years ago the first commercial cracking units went into operation at the Standard Oil of Indiana Whiting plant, using shell stills having a capacity of about 200 barrels of gas oil per day with a yield of about 30 per cent. To-day, a single topping and cracking unit with polymerization of the cracked gases treats more than 30,000 barrels a day of crude oil with yields of over 70 per cent. of 70 octane gasoline from crude oils derived from East Texas. The cost of such a unit is about $2,000,000 whereas the early shell still cost about $20,000.

Modern cracking installations have been highly flexible since the introduction of multiple heating coils in equiflux furnaces wherein the time, temperature and pressure conditions may be maintained to a nicety. Two-day runs were the maximum in shell-still operation, whereas the modern installation—composed of heaters, reaction chamber, flash chamber, fractionator, coolers and stabilizers—operates continuously for months at a time, producing motor fuel, furnace oil, tractor fuel, fuel oil and gas oil, or gasoline, gas and coke.

The early shell stills (1913) used cracking temperatures around 740° F. and 75 p.s.i.; to-day temperatures ranging from 900 to more than 1,100° F. and more than 1,000 p.s.i. obtain. The yield of gasoline from gas oil was about 30 per cent. with octane rating of 60; to-day units operating on the same type of gas oil produce more than 70 per cent. of motor fuel with 74 octane rating.

The increasing number of high-compression motors

has made straight-run gasoline no longer suitable as fuel. Cracking or reforming of the gasoline is necessary to produce hydrocarbons of structures which possess greater anti-knock properties. In order to convert the knocking gasoline into non-knocking types, it is desirable to subject the gasoline to temperatures of the order of 1,025° F. and 750 p.s.i. This is accomplished by pumping straight-run gasoline through a long heating coil distributed in a furnace, until the temperature and pressure are raised to convert the hydrocarbons into high anti-knock gasoline. Under these drastic temperatures and pressures, there is a molecular rearrangement and change in the structures of the hydrocarbons from the straight-chain paraffinic type to branched paraffins, olefins, aromatics and naphthenes. These hydrocarbons burn without detonation in the high-compression motors of to-day.

It was recognized that thermally cracked gasoline was approaching a limit from the anti-knock quality standpoint. The octane number averaged about 70 as produced from gasoline, naphthas, or heavy oils. Hence, catalytic cracking processes have been developed to increase the octane rating and yields above that of thermal. Catalytic cracked gasoline of 80 octane has been produced from gas oil with yields of 85 per cent. on a recycle basis. Catalytic cracking will be an adjunct to thermal cracking for some time to come. An important part of the catalytic cracking process is the quality of the gas produced since the percentage of olefins present is generally more than double that of thermal cracked gas.

The gases produced from the cracking process amount to over 350,000,000,000 cu. ft. a year. These hydrocarbon gases were burned under stills and boilers. But these gases contained olefins such as ethene, propene, butenes and the corresponding paraffins—ethane, propane and butanes. Several processes were developed to convert cracked gases into high octane motor fuel via high temperatures and pressures while the catalytic process using solid phosphoric acid operates at low temperatures and pressures.

There are over 80 U.O.P. catalytic polymerization units in commercial operation, design, or under course of construction at the present time. The capacities of these units, processing cracked gases range from 125,000 cubic feet to 27,000,000, or on a gasoline (81 octane) production basis, from 18 barrels to over 2,500 barrels daily. The combination of selective catalytic polymerization and hydrogenation units produce from 50 barrels to 800 barrels of isooctane gasoline per day. The increased yield of gasoline ranges from two to eight per cent with an octane number rise of one to two on the refinery gasoline output when processing naphtha, kerosene, gas oil, or topped crudes.

The butane-butene fractions from either the cracking or dehydrogenation process may be catalytically polymerized to yield isooctenes, and upon hydrogenation, isooctanes of 95 to 100 octane rating. The conditions for the manufacture of isooctane require temperatures of 250° to 350° F. and approximately 750 p.s.i. with solid phosphoric acid as the catalyst. Debutanization and rerunning of the polymers is carried out and finally catalytic hydrogenation with nickel yields an aviation gasoline of 97 octane rating. The potential yearly production of polymer gasoline is over 300,000,000 barrels derivable from refinery and natural gases.

For years it was believed impossible to react a paraffin with an olefin hydrocarbon, due to the so-called unreactiveness of the paraffins. A new page in organic chemistry has been written based upon an alkylation of isobutane with ethene, propene, and butenes by a number of methods such as aluminum chloride, boron fluoride, sulfuric acid, and at high temperatures and pressures. The latter two processes have gone into commercial use in the past year and are an exceedingly important contribution to high octane aviation gasoline. These two processes produce products having about 95 octane rating and high tetraethyl lead susceptibility. The thermal alkylation process operates best when using charging stocks made up of isobutane and ethene, producing therefrom 2, 2-dimethylbutane or neohexane, whereas the sulfuric acid method functions best on isobutane and butenes, forming isooctanes. When all the alkylation units under design and construction, as well as those in operation, are functioning, about 4,000,000 barrels of high anti-knock aviation gasoline will be produced annually.

Military airplanes in 1928 used gasoline of about 60 octane rating while three years later the standard Army aviation gasoline was 87 octane. Airplane engines were developed to utilize this fuel which gave a 33 per cent. increase in power per unit weight compared to 60 octane gasoline. Engines designed for using 100 octane gasoline produced 30 per cent. greater power output compared to 87 octane, while take-off distances were reduced 20 per cent and climbing speed increased 40 per cent. For transport planes, the advantage of 100 over 87 octane gasoline in a 1,400 mile flight would be the dispensing of "1,200 lbs. of gasoline and carrying instead 7 more passengers, or their equivalent weight in mail or freight."

Leadership in aviation gasoline, with higher speeds and comfort of airplanes, rests in the United States. Aviation gasoline of 100 and higher octane can be produced in the United States in quantities to supply the airplane needs of the world, for civil and military use. A most significant factor in the development of 100-octane gasoline is that the overall efficiency of the

airplane gasoline engine is about the same as that of the best Diesel airplane engine performance and in addition surpasses the Diesel in greater take-off and emergency power and flexibility in maneuvering the plane.

Although 100 octane gasolines and higher are now used only in airplanes, it will not be many years before the oil industry's researches will produce them at a price level for use in passenger, truck, and bus vehicles, and they will be sharply competitive with the best high-speed Diesel engine performance.

Dr. Graham Edgar stated:

> The General Motors Corporation carried out an elaborate research project in which an automobile equipped with a valve-in-head engine was operated at a number of compression ratios and a number of gear ratios, using fuels which in each case were just capable of avoiding knock. Approximately 69 octane fuel was required for the standard 5.25 compression ratio, about 95 octane for 8.0 compression ratio, and something better than 100 octane for 10.3 compression ratio.
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> The results were most striking, showing, for example, that at 40 miles per hour the miles per gallon improved from 12.5 at 5.25 compression ratio to 18 at 8.0 and 21 at 10.3. The average increase in economy, between ten and sixty miles per hour, is about 45 per cent. in going from 5.25 to 8.0 compression ratio under these conditions of constant performance.
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> It is interesting to note that if we take the average retail price of gasoline as 19 cents per gallon, the driver of the 8.0 compression car could have paid 27.5 cents per gallon at no increase in cents per mile, which would give the refiner a margin of 8.5 cents per gallon above his regular costs of 5 cents per gallon with which to attempt to produce the 95 octane gasoline required by the high compression car. Certainly, such an achievement would appear to be well within the eventual possibilities of the refinery technologist.

The volumes of 100 octane gasoline potentially available yearly in the United States are greater than the volume of all gasolines now being produced. One prolific source which has been tapped recently is natural and refinery gases. From these gases alone 8,345,000,000 gal. of 81 octane, or 3,275,000,000 gal. of 92 octane, unleaded, gasolines are available. About 6,000,000,000 gal. of 100 octane aviation gasoline are available yearly when the 92 octane is blended with isopentane and neohexan and light ends from some crudes plus tetraethyl lead. This volume of aviation gasoline does not take into consideration the vast volumes of aviation stock which are potentially available from catalytic reforming and cracking.

The development of catalytic dehydrogenation of gaseous paraffins to olefins and hydrogen has made possible their utilization for polymerization to gasoline and chemical derivatives. Thermal cracking of paraffin gases is a competing source of olefins; however, catalytic dehydrogenation gives a better yield of the desired products than the thermal method. Catalytic dehydrogenation of ethane, propane, and butanes is highly selective in that side reactions are suppressed. Catalysts for dehydrogenation reactions are oxides of the metals of the fourth, fifth, and sixth group of the periodic system, the most important one being chromium oxide and alumina. This catalyst is highly selective and converts the paraffin to the corresponding olefin in about 85 to 95 per cent. of theoretical.

Butane may also be converted into butadiene by a two-stage catalytic dehydrogenation process. This compound is extremely important for use in synthetic rubber production. Butadiene is available potentially in the U.S. at the rate of more than 160,000,000,000 pounds yearly.

There is a very beautiful reaction called cyclization of paraffin hydrocarbons; *i.e.,* catalytically converting normal hexane, heptane and octane into benzene, toluene and xylenes respectively, with hydrogen as a by-product and almost theoretical yields.

The lower-boiling hydrocarbons in petroleum, particularly those from the Pennsylvania, Mid-Continent, Michigan, East Texas, and Kettleman Hills, California, fields, and gasoline from natural gas, are predominantly straight-chain paraffins. By catalytic cyclization at 932° F. and atmospheric pressure, these hydrocarbons may be converted into the corresponding aromatics which have been obtained heretofore chiefly from coal carbonization.

As of to-day, the aromatic hydrocarbons are not so good for airplane use, although some tests indicate that they will become useful. They are excellent blending hydrocarbons for increasing the octane rating of gasolines.

Benzene, toluene and xylenes are most important for motor fuel use and as basic material for high explosives such as picric acid, T.N.T., and trinitroxylenes. The oil industry can produce any conceivable amount of these hydrocarbons from catalytic cyclization or aromatization of gasoline, the cracking process, and dehydrogenation of ethane. In 1940 about 26,000,000,000 gallons of gasoline will be produced in the United States. If the demand were present, our gasoline output could be increased to over 40,000,000,000 gallons in a short time. Based on this year's gasoline production alone, and using but 20 per cent. of the gasoline, the U.S.A. could manufacture (naturally requiring some time to go into full production) about 33,000,000,000 pounds of picric acid, about 27,000,000,000 pounds of T.N.T., and 25,000,000,000 pounds of trinitroxylene. The 85,000,000,000 pounds of high

explosives which are potentially available from gasoline are all present within the shores of the U.S.A. and for many years to come.

In the world war now going on, difficulty will be experienced in obtaining natural rubber for our own needs. It is reported that the United States has but a three months' supply of natural rubber. Some suggestion has been made to plant rubber trees in a South American country such as Brazil. It would require at least ten years to obtain rubber in this way. Benzene and ethylene through alkylation and dehydrogenation yield styrene, a starting hydrocarbon for synthetic rubber manufacture. Butadiene is another hydrocarbon which can be readily produced and converted into synthetic rubber or may be copolymerized with styrene. This latter type of synthetic rubber has about 30 per cent. greater wear quality and strength in tires than natural rubber. The United States has potentially available enormous quantities of these hydrocarbons and other substances which can be converted into synthetic rubbers. In 1939 about 1,100,000,000 pounds of natural rubber were used in this country. Over 200,000,000,000 pounds of synthetic rubber could be produced from ethylene from the cracking process, benzene from cyclization, and butadiene from the dehydrogenation of butane. A unit to produce 10,000 pounds a day of synthetic rubber from butadiene derived from petroleum is being installed.

The U.S.A. can be more than self-sustaining in synthetic rubber from its own vast hydrocarbon resources.

The U.S.A. is more than self-sustaining in motor fuels and aviation gasoline of 100 octane and above. The U.S.A. can produce billions of pounds of explosives for any necessity that may arise and still have more than sufficient gasoline for any form of transportation on land, air, or sea.

OBITUARY

WILFRED THOMAS DAWSON

WILFRED THOMAS DAWSON, late professor of pharmacology at the Medical Branch of The University of Texas, was born in Windsor, Nova Scotia, on October 3, 1895. He was the son of John Leard Dawson and Florence Lockhart Dawson. He died suddenly on September 19, 1939, at Galveston, Texas.

He was married to Miss Margaret Bishop on September 11, 1926. Their son, Wilfred Thomas, Jr., was born on September 14, 1928. In addition to his widow and son he is survived by two brothers, Kenneth Leard Dawson of Halifax, N. S., and John Chesley Dawson of Quebec.

In 1914 he was graduated from Mount Allison College and the following year received his A.M. in chemistry from that institution. He taught mathematics at the Prince of Wales College during 1915–16. In 1916 he was appointed a Rhodes Scholar at Exeter College, Oxford University. The scholarship was deferred on account of the war.

He enlisted as a private in the heavy artillery of the Canadian Expeditionary Forces and served with distinction through the war. He was discharged in 1919 as a lieutenant.

After the Armistice, he was one of the organizers and professor of chemistry of the Khaki University of the Canadian Expeditionary Forces in England.

In 1919 he took up his Rhodes Scholarship at Oxford and worked there from 1919–1922. He was especially interested in physiology, pharmacology and allied subjects. He received his A.B. in 1923 and in 1927 an A.M. in physiology.

During 1922–1923 he was connected with the physiology department, University of Pennsylvania, and from 1923–1925 was acting professor of physiology and pharmacology at the Women's Medical College of Pennsylvania.

In 1925 he came to the medical branch of the University of Texas as associate professor of physiology and the next year became associate professor of pharmacology. In 1927 he was appointed professor of pharmacology and pharmacologist at the John Sealy Hospital. He filled both positions with distinction.

During the summers he was associated with the division of biological sciences of the University of Chicago, the department of pure research of the Mellon Institute and attended meetings of the Cowles Commission for Research in Economics.

He was a member of the National Malaria Committee, the American Association for the Advancement of Science, the American Physiological Society, the American Society for Pharmacology and Experimental Therapeutics, the Society for Experimental Biology and Medicine, the Society for Tropical Medicine, Oxford Society and the American Association for Rhodes Scholars.

His research interests were varied, including congenital heart disease, carbon monoxide poisoning, chemical structure and physiological activity. He published many papers on the cinchona alkaloids, treatment of malaria, the action of barbiturates as strychnine antidotes and cardiac glucosides. He was very much interested in biological statistics, especially as related to problems of dosage and toxicity.

Professor Dawson was an inspiring teacher. He possessed an unusual command of English and made his points with great clarity. He had a catholicity of taste in reading that is seldom found in a scientific

man. He was familiar with the classics and kept abreast of modern literature. He was fond of discussing what he had read and it was a real treat to hear him tell of some book he had especially enjoyed.

The students looked to him for assistance in both their personal and professional problems and were greatly helped by his guidance.

He will be sorely missed by his colleagues at the Medical Branch of the University of Texas as well as by his many friends here and abroad, not only for his brilliant scientific ability but for his many friendly personal traits.

Truly one of his charity and tolerance can ill be spared in these days of trouble and stress.

CHARLES H. TAFT, JR.

THE UNIVERSITY OF TEXAS

RECENT DEATHS

DR. FREDERICK JAMES EUGÉNE WOODBRIDGE, Johnsonian professor emeritus of philosophy at Columbia University and until 1929 dean of the graduate faculties, died on June 1. He was seventy-three years old.

DR. WILLIS STANLEY BLATCHLEY, who was state geologist of Indiana from 1894 to 1911 and who was known for his work on the Orthoptera, Heteroptera and Coleoptera of the Eastern United States and Canada, died on May 28 at the age of eighty years.

DR. WILLIAM FREDERICK BOOK, emeritus professor of psychology at Indiana University, died on May 22 at the age of sixty-six years.

DR. GEORGE GIBBS, consulting engineer to railroads in the United States and England, died on May 19 at the age of seventy-nine years.

THE death is announced at the age of seventy-five years of Paul Mellen Chamberlain, consulting mechanical engineer, of Newark, N. J., who was from 1896 to 1906 professor of mechanical engineering at Lewis Institute, Chicago.

CHARLES SUMNER TAINTER, physicist and inventor, of San Diego, died on April 20 at the age of eighty-six years.

DR. RAYMOND E. DOUGLAS, professor of zoology at Houghton College, New York, died on May 18 in his forty-fourth year.

DR. RALPH VORIS, since 1928 professor of biology at Southwest Missouri State Teachers College, died on May 9 in his thirty-eighth year.

DR. CLARENCE JEROME ELMORE, head of the department of biology of William Jewell College, died on May 19 at the age of seventy years. He is best known for a monograph on the Diatoms of Nebraska.

SCIENTIFIC EVENTS

A SYMPOSIUM ON HYDROBIOLOGY AT THE UNIVERSITY OF WISCONSIN

A SYMPOSIUM ON HYDROBIOLOGY will be held at the University of Wisconsin from September 4 to 6, the general program for which has been completed and will soon be distributed. It comprises a series of papers and round-table discussions dealing with the various phases of hydrobiology. From an environmental standpoint, consideration is given to some of the allied sciences as well as to purely biological subjects.

In geology the chief topics of discussion are the sediments of both natural and artificial lakes and the factors which affect their character and extent. The chief topic in physics centers around the penetration of solar radiation into natural waters and the consequent changes in intensity and spectral composition with depth; the biological implications of these problems are also listed for discussion. Chemistry is represented by a paper on dissolved oxygen and lake typology.

The biological part of the program deals with such problems as the photosynthesis of bacteria and algae and the rôle of bacteria, fungi and large aquatic plants in the biology of natural waters. The ichthyological topics include the rate of growth and the speciation of fish as affected by environmental factors, problems in physiology and reproduction, the fish production of lakes and streams and pond fish farming. The social and economic implications of inland lakes will be discussed at an evening session.

The sanitary science section will consider various problems relating to inland waters and public health, including such subjects as pollution and its prevention, water supplies, control of malaria and schistosome dermatitis (swimmer's itch) and the chemical control of algal growths in lakes.

The afternoon session on September 5 will consist of fifteen-minute volunteer papers, and hydrobiologists are cordially invited to participate in this part of the program.

On Thursday evening a dinner will be held in honor of President Emeritus Edward A. Birge, who began his hydrobiological investigations in Wisconsin in 1875 and is still actively engaged in such studies.

THE SEVENTY-FIRST ANNUAL REPORT OF THE AMERICAN MUSEUM OF NATURAL HISTORY

THE annual report of the American Museum of Natural History of New York City has been issued. It

opens with statements by the president, F. Trubee Davison, and the director, Dr. Roy Chapman Andrews.

The report of the director states:

The year 1939 was distinguished for the amount of new material placed on exhibition.

Ten years ago Harry Payne Whitney gave three quarters of a million dollars, matched by the city, to construct the Whitney Wing. Now this building stands as a model museum unit. Eight groups in the Hall of Pacific Island Birds were finished at the time of the formal opening in June, and a ninth is being built through the generosity of Richard Archbold. Cornelius Vanderbilt Whitney, adding to the already great benefactions of himself and his family, has given funds for the completion of the remaining groups, so that this hall, one of the loveliest in the entire museum, will be finished as soon as we can gather and prepare the requisite material.

Mr. Andrews reports that with the installation of two groups in 1939 the entire second floor of the Akeley African Hall is now completed. One expedition is at present in Africa collecting materials for two groups, and as soon as seasonal conditions are favorable, a collector will secure specimens of the cheetah. This is the final group, and in the not distant future the entire exhibit will be complete.

For many years all fossil reptile specimens on exhibition have been crowded into one hall. The addition of the new Jurassic Hall, opened this year, provides space not only for the visitor to see the larger mounted skeletons in a proper perspective, but for an arrangement of the fossil reptile collection as a whole in chronologic order from the early Permian forms to those of the late Cretaceous.

In the new North American Mammal Hall the group of Rocky Mountain goats is finished, and the construction and preparation staffs are engaged in preparing cases and group accessories and animals for the remainder. Funds, the vital necessity before any construction can be undertaken, have been pledged by various friends and benefactors for all the larger groups in this hall.

Summarizing the accomplishments of the Ten Year Development Program for 1939 it is stated in the report that 1,235 subscriptions were received from all sources amounting to $133,825, of which $121,869 is applicable to 1939 operation; a new activity in 1939 enlisted New York City members in a membership campaign. Three hundred and fifty new members were obtained and the ground-work has been laid for further development. The Women's Century Fund Committee, under the chairmanship of Mrs. Winthrop W. Aldrich, raised $23,109 during the year, and the Men's Committee, with Mr. S. Sloan Colt as chairman, obtained $51,875. The efforts of the program in 1939 resulted in raising the amount needed to balance the budget and provided a cash reserve for 1940.

THE EIGHTH SUMMER CONFERENCE ON APPLIED SPECTROSCOPY AT THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

A PROGRAM of some thirty papers on the applications of spectroscopy to problems of biology, chemistry, geology, metallurgy, medicine, physics and various industries has been arranged for the eighth summer conference on spectroscopy and its applications, to be held in the George Eastman Laboratories of the Massachusetts Institute of Technology on July 15, 16 and 17.

As in previous years, morning and afternoon sessions will be held on all three days. The earlier sessions will be devoted to discussion of recent advances in spectrographic analysis of materials, both by emission and absorption methods, while later sessions will deal with specific applications of these techniques to the various scientific and industrial fields. The type of material to be discussed is represented in the proceedings of the fifth, sixth and seventh conferences, published by John Wiley and Sons.

Copies of the detailed program of the conference will be sent on request to any one interested. Since the attendance is limited to two hundred, and as there are usually more than this number of applications, persons expecting to attend from a distance are urged to write in advance for reservations. No fees of any kind are charged in connection with the conference.

The usual summer courses on practical and applied spectroscopy and a new course on line spectra will be offered between June 12 and July 22. Requests for special bulletins describing courses and conference, for reservations at the conference or for the conference program, should be addressed to Professor George R. Harrison, Department of Physics, Massachusetts Institute of Technology, Cambridge, Mass.

THE BICENTENNIAL CONFERENCE OF THE UNIVERSITY OF PENNSYLVANIA

A BICENTENNIAL CONFERENCE will be held by the University of Pennsylvania, beginning on September 16 and closing on September 20, as part of the program marking the observance of the two hundredth anniversary of the founding of the university. Membership in the conference will be by application, and is open, within the limit of accommodations, to members of the staffs of invited institutions and organizations.

The program will consist of lectures and papers by a group of distinguished European and American scholars and leaders in the various fields of science and

thought. The offerings will represent the broad interests and significant contributions to learning. In the field of the humanities the symposia are planned to bring out the continuity of culture. In other fields they will deal with trends of modern thought and the advances of science. Each paper is on a topic on which the published writings and researches of the speaker give him a peculiar right to speak.

An elaborate series of lectures and symposia has been arranged. In the natural sciences, lectures announced for September 17, 18 and 19 are:

Subject to be announced. Sir Robert Robinson, Waynflete professor of chemistry, University of Oxford.

Engineering Progress and the Social Order. Dr. Frank Baldwin Jewett, president, Bell Telephone Laboratories, New York City; president, National Academy of Sciences, Washington.

The Beginnings of Social Behavior in Unicellular Organisms. Dr. Herbert Spencer Jennings, professor of zoology, University of California.

Aspects of Modern Psychology. Dr. Charles Samuel Myers, formerly director of Psychology Laboratory, University of Cambridge.

According to the preliminary program the following symposia will be presented:

Botany—Fundamental Aspects of the Problem of the Conservation of Renewable Natural Resources; History of Sciences—Round Table; Chemistry—Chemical Kinetics; Natural Products; Engineering—Fluid Mechanics; Statistical Methods in Engineering; Zoology—Cytology, Genetics and Evolution; Cytogenetics and Evolution; Cytology and Genetics of Protozoa; Physiology of the Nucleus; Psychology—Contributions of Psychology to Education and Business; Physics—Nuclear Physics, and Geology—The Geophysical and Paleontological Problems in Shiftings of Sea Floors and Coast Lines.

In the Medical Sciences lectures are announced as follows:

Subject to be announced. Dr. Thorvald Madsen, director, State Serum Institute, Copenhagen, and chairman of the Health Committee of the League of Nations.

The Study of Man. Dr. Lawrence Joseph Henderson, professor of biological chemistry, Harvard University.

Two Centuries of Surgery. Dr. Evarts Ambrose Graham, Rixby professor of surgery, School of Medicine, Washington University, St. Louis.

A Challenge to Scholarship. Dr. William Mansfield Clark, director of the department of physiological chemistry, the Johns Hopkins University.

The subjects of the symposia in the Medical Sciences are:

Problems and Trends in Virus Research, Therapeutic Advances in Psychiatry, Medical Problems of Old Age, Nutrition, Female Sex Hormones, Clinical Considerations, Hypertension, Genesis of Cancer, Dental Caries, Development of Occlusion, Intestinal Obstruction, The Relation of Diseases in Lower Animals to Human Welfare, Modern Aspects of the Antituberculosis Problem, Chemotherapy, The University and Public Health Statesmanship.

Throughout the week there will be dinners and entertainments in the evening. On Thursday night a University Bicentennial Concert will be given by the Philadelphia Orchestra at the Academy of Music. A Fête on the Schuylkill River in Fairmount Park will be held on Friday night. It is hoped that those who are able to attend the conference will remain for these events.

SCIENTIFIC NOTES AND NEWS

THE ninety-first annual session of the American Medical Association will be held in New York City from June 10 to 14. At the opening general meeting at the Waldorf-Astoria on the evening of June 11, the association will be welcomed to New York by Governor Herbert H. Lehman and by Mayor Fiorella La Guardia, following which the president-elect, Dr. Nathan B. Van Etten, of New York City, will be introduced and installed as president of the association and will deliver his presidential address. A medal will be presented to the retiring president, Dr. Rock Sleyster, of Wisconsin, and the distinguished service medal will be presented to Dr. Van Etten.

UNDER President Roosevelt's reorganization plan, the Bureau of the Biological Survey, hitherto in the Department of Agriculture, and the Bureau of Fisheries, hitherto in the Department of Commerce, were on June 1 merged with the name of "Fish and Wildlife Service" and were placed under the Department of the Interior. Dr. Ira N. Gabrielson, who was chief of the Biological Survey, has been appointed head of the new service. Charles E. Jackson, acting commissioner of fisheries, and W. C. Henderson, associate chief of the Biological Survey, have been made assistant directors.

DR. VLADIMIR N. IPATIEFF, director of chemical research of the Universal Oil Products Company, Chicago, and professor emeritus of chemistry of Northwestern University, received the 1940 Willard Gibbs Medal at a dinner meeting of the Chicago Section of the American Chemical Society on May 23. Dr. Ipatieff, who was born in Moscow in 1867, was cited for chemical discoveries basic to petroleum refining and to the organic synthesis of artificial rubber and of many other industrial products. The medal presentation was made by Dean Samuel C. Lind, of the Institute of Technology of the University of Minnesota, president of the American Chemical Society.

Dr. Cary R. Wagner, of the Pure Oil Company, chairman of the Chicago Section, presided and discussed the origin and significance of the Willard Gibbs Medal award. Professor Paul Haensel, of Northwestern University, spoke on "Ipatieff the Man," and Dr. Gustav Egloff, director of research of the Universal Oil Products Company, on "Ipatieff and His Chemical Achievements." The Willard Gibbs address was given on the following day at Northwestern University. Following the reading of the address, President Franklyn B. Snyder, of Northwestern University, unveiled a portrait of Dr. Ipatieff, painted by John Doctoroff, the Russian-American artist. The program was concluded with an open house in the High Pressure Laboratory which Dr. Ipatieff endowed last year.

THE Lamme Medal, given each year to an alumnus of the Ohio State University distinguishing himself in the field of engineering, has been awarded to Lawrence Eugene Barringer, engineer in charge of insulations of the General Electric Company, Schenectady, N. Y. The presentation will be made at the commencement of the university on June 10.

THE Casselberry Prize of the American Laryngological Association has been awarded to Dr. French K. Hansel, of St. Louis, for original cytologic observations of the secretions of the nose and sinuses in allergy.

FOR his study of the life cycle of the fungus, *Histoplasm capsulatum,* Dr. Norman F. Conant, assistant professor of bacteriology and mycology at the School of Medicine of Duke University, has been named winner of the Poteat award of $50 given annually by the North Carolina Academy of Science.

THE New York Academy of Medicine has awarded the Alexander Cochran Bowen scholarship for 1940 to Dr. Everett D. Sugarbaker, surgical resident at the Memorial Hospital, New York City. The Harlow Brooks scholarship for 1940 has been awarded to Dr. Henry Aranow, Jr., intern at the Presbyterian Hospital. These scholarships provide for one year's graduate medical education.

A DINNER was given by his former students on April 7 in honor of Dr. George O. Higley, who retired in 1929 as professor of chemistry at the Ohio Wesleyan University.

COLONEL RAM NATH CHOPRA, head of the faculty of pharmacology in the School of Tropical Medicine, Calcutta, has been elected an honorary member of the Pharmaceutical Society of Great Britain.

THE degree of doctor of science will be conferred by the University of Oxford on Dr. Mariano Rafael Castex, at one time rector and for more than twenty-five years professor of medicine in the University of Buenos Aires.

AT the sixty-second meeting of the American Laryngological Association at Harrison, N. Y., Dr. Gordon Berry, of Worcester, Mass., was elected president; Dr. Charles T. Porter, of Boston, first vice-president, and Dr. Gordon F. Harkness, of Davenport, Iowa, second vice-president.

CLAUDE F. DAVIS, chief chemist of the Noblesville Milling Company, Indiana, was elected at the twenty-sixth annual meeting in New York City president of the American Association of Cereal Chemists. He succeeds George F. Garnatz, chief of laboratories, Kroger Food Foundation, Cincinnati, Ohio. Dr. Charles N. Frey, head of the Research Laboratories, Standard Brands, Incorporated, New York, was elected vice-president.

DR. FRANCIS G. BLAKE, Sterling professor of medicine at the Yale University School of Medicine, has been appointed acting dean of the school to succeed Dr. Stanhope Bayne-Jones, who will retire on July 1.

DR. MAURICE EWING, who has been on leave of absence for the last two years on a Guggenheim Fellowship, has been appointed associate professor of geophysics in the department of geology at Lehigh University.

DR. VALY MENKIN has been advanced to the rank of assistant professor of pathology at the Harvard Medical School.

DR. W. SUCKSMITH has been appointed professor of physics at the University of Sheffield in succession to Professor S. R. Milner, who is retiring at the end of the present session.

DR. ROBERT V. DREXLER, of the department of botany of the University of Illinois, has been appointed to an instructorship in the department of biology of Coe College, Cedar Rapids, Iowa.

THE position of Dr. Robert Calvert with the Johns-Manville Corporation is "consultant," not chief chemist, as was stated in a note in a recent issue of SCIENCE.

DR. EDWARD E. MARBAKER, who has been for twenty years a fellow of the Mellon Institute, has been appointed to the industrial fellowship founded by the O. Hommel Company, of Pittsburgh, manufacturers of ceramic chemicals and colors and bronze powders. The fellowship has been established for the joint purpose of carrying on a broad program of scientific investigation and of maintaining contact with existing professional agencies.

DR. JOSEPH P. CONNOLLY, president of the South Dakota School of Mines, will have charge of research of a joint paleontological expedition of the National

Geographic Society and the school to be made in the West this summer in an effort to discover remains of New World types of rhinoceros.

DR. CASWELL GRAVE, Rebstock professor of zoology at Washington University, St. Louis, gave the address at the annual joint meeting of the Washington University chapters of Phi Beta Kappa and Sigma Xi. His subject was "Washington University: Prospect from Retrospect."

THE summer convention of the American Institute of Electrical Engineers will be held at Toronto from June 16 to 20.

THE two hundred and thirty-fifth regular meeting of the American Physical Society will be held at the University of Washington, Seattle, from June 18 to 22. On Tuesday afternoon there will be a joint session with the American Association of Physics Teachers. The program for Wednesday morning will consist of a symposium on cosmic rays, followed on Wednesday afternoon by a joint meeting with the Astronomical Society of the Pacific. On Thursday afternoon there will be a symposium on theoretical physics. Sessions for the presentation of short contributed papers will be held on Friday morning and afternoon and on Saturday morning. The two hundred and thirty-sixth meeting will be held in Pittsburgh on June 20, 21 and 22. The plans of the local committee include tours of industrial laboratories and plants, a program of invited papers on applied physics topics and sessions of contributed papers. Plans for social entertainment include a tea at the Cathedral of Learning of the University of Pittsburgh on Thursday afternoon, and attendance at a special Westinghouse musical broadcast on that evening. There will be a dinner on Friday evening at the Webster Hall Hotel.

THE Western Section of the American Society for Horticultural Science will participate in the meetings of the American Association for the Advancement of Science to be held in Seattle, Wash., from June 18 to 22. The program of the section extends over three days. On Wednesday, June 19, a joint session will be held with the American Society of Plant Physiologists, and also a full half-day program will be devoted to the responses of horticultural crops to soil nutrients. On Thursday, there will be a joint session with the Northwest Association of Horticulturists, Entomologists and Plant Physiologists and a half-day program of unrelated horticultural papers, and on Friday a further half-day session for horticultural papers. Information can be obtained from Director John H. Hanley, the University of Washington Arboretum, 202 Anderson Hall, College of Forestry, Seattle.

THE 1940 Graduate Fortnight of the New York Academy of Medicine will be held from October 14 to 25. The subject this year is "Infections." Its purpose is to make a complete study and authoritative presentation of a subject of outstanding importance in the practice of medicine and surgery. A carefully integrated program will be presented. It will include morning panel discussions, afternoon clinics and clinical demonstrations at many of the hospitals of New York City, evening addresses and appropriate exhibits. The evening sessions at the academy will be addressed by recognized authorities in their special fields, drawn from leading medical centers of the United States. A comprehensive exhibit will include books and roentgenograms; pathological and research material; and clinical and laboratory diagnostic and therapeutic methods. It is planned to provide demonstrations of exhibits. A complete program and registration blank may be secured by addressing Dr. Mahlon Ashford, The New York Academy of Medicine, 2 East 103d Street, New York City.

THE program of the symposium organized by the Society for the Study of Development and Growth, which will be held at Salsbury Cove, Maine, from June 20 to 25, is as follows: June 20, "Structure of Protoplasm," Dr. O. L. Sponsler, University of California at Los Angeles; "Synthesis of Protoplasmic Constituents," Dr. Rudolf Schoenheimer, Columbia University. June 21, "Colloid Chemistry of Development and Growth," Dr. Herbert Freundlich, University of Minnesota; "Chemical Factors of Growth," Professor George S. Avery, Jr., Connecticut College. June 22, "Physical Factors of Growth," Professor Douglas Whitaker, Stanford University. June 24, "Cell Division and Development," Professor A. B. Dawson, Harvard University; "Size-Controlling Factors," Professor Victor C. Twitty, Stanford University. June 25, "Pathology of Development," Dr. Harry S. N. Greene, Rockefeller Institute; "Theories of Organization," Professor F. S. C. Northrop, Yale University. The discussion leaders are: Dr. Edward F. Adolph, University of Rochester; Professor R. G. Harrison, Yale University; Dr. Stanley P. Reimann, Lankenau Hospital; Professor Kenneth V. Thimann, Harvard University; Professor B. H. Willier, University of Rochester, and Dr. Dorothy M. Wrinch, University of Oxford.

KANSAS STATE COLLEGE is the recipient of a gift of a hundred and sixty acres of high prairie land from Dr. C. L. Marlatt, of the class of 1884, formerly chief entomologist of the Bureau of Entomology, U. S. Department of Agriculture, and Dr. Abby Marlatt, of the class of 1888. Situated four miles from the college campus, the land is to be used as a natural area and as a recreation ground for students and faculty of the college. The gift is in memory of Washington Marlatt, father of the donors and one of the founders of Bluemont Central College, established in 1858 and transferred to the state in 1863.

DISCUSSION

A MAJOR CYCLE IN INSECT FLIGHTS

FROM June 1 to September 15, 1939, a period of unusually uniform and predominantly fair weather in northeast Georgia, a nightly record was kept of the insects which were attracted to a neon-mercury light trap in operation from dusk until 1:00 A.M. at Demorest, Habersham County. By an actual count of certain insect types representative of entire catches, a rather accurate estimate could be gained of the extent of insect aerial activity for each evening. These index forms, which waxed and waned independently throughout the season, included all moths, micro as well as macro, small scarabaeid beetles of the genera *Aphodius* and *Ataenius,* carabid beetles of the genus *Harpalus,* scolytid beetles of the genus *Xyleborus* and a minute, reddish brown cydnid bug, *Amnestus pusillus* Uhler.[1] The last two named often came in swarms during the early part of the evening and, over the four or five weeks of their dominance, constituted dependable indicators of general flight conditions.

During the course of these observations, several remarkable flights were recorded. The evenings on which they occurred stood out in marked contrast not only to the average night of fair yield but even to the less frequent occasions when yields were relatively large. On June 6, 7, 22, July 5, 22, August 18, 19 and September 4, from dusk until midnight, thousands of insects (on August 19, tens of thousands) came to light and were trapped, a phenomenon which was out of all proportion to the hundreds or even tens captured on other evenings. According to a solar-lunar gravitational table,[2] these dates coincide exactly with periods when the combined pull of the sun and moon acted tangentially on the earth at the appropriate meridian during the hours from 10:30 P.M. till 12:30 A.M. The only similar period included in this series of observations which was not characterized by insect flights of especially great magnitude was coincident with two successive evenings (August 5 and 6) featuring heavy thunderstorms followed by a pronounced drop in temperature. However, there was every indication, judging by the progressively increasing numbers of flyers on August 3 and 4, that conditions were building up for a major movement on the 5th and 6th, an event which most probably would have taken place had the weather remained congenial. As though in compensation for a thwarted impulse, the flights during the subsequent swarming period, August 18 and 19, were the heaviest of the entire season. Midway between the times of intense nocturnal activity was noted a much less clearly defined cycle of minor flights, while few or sometimes almost no insects came to light on intervening dates. Although cold or windy weather may noticeably restrain nocturnal insects, temperature seems not to be the primary factor in determining whether or not they will take to the air en masse. This is clearly indicated by the observation that, on several supposedly ideal flying evenings when the atmosphere was sultry and warm (70° F. or more at midnight), the turnouts were only fair or even poor; whereas it was somewhat cooler (68° F.) on the night of August 19 when the greatest flight among 76 consecutive recordings took place.

It therefore seems quite possible that nocturnal swarmings of insects, presumably essentially nuptial in character, are governed in some way by gravitational or related forces. At any rate, it appears fairly certain that such mass movements are cyclic and broadly predictable, recurring every 13 to 17 days so long as season and weather permit. Striking confirmation of this periodicity comes from data collected by the writer in Fiji. There, at an altitude of 2,600 feet, thousands of miscellaneous insects (mostly *Lepidoptera, Coleoptera* and *Hemiptera*) arrived at light on the evenings of October 6, 7, 21 and 22, 1937, despite low temperatures and showers, while at the identical spot on all other nights, mild or cool, from October 3 to the end of operations on the 28th, the collecting sheets were virtually empty; and in the lowlands, the first spectacular spring flights since collecting began in July were recorded on September 23 and 24 when the temperature (70° F.) was far from unusually high.

J. MANSON VALENTINE,
Dazian Fellow

SOMERSET, VA.

[1] The writer is indebted for determinations to Dr. E. A. Chapin, Dr. M. W. Blackman and Mr. H. G. Barber of the U. S. National Museum.

[2] J. A. Knight's "Solunar Tables" for 1939.

CALCIUM CARBONATE DEPOSITS MARGINAL TO GLACIERS

BLACKFEET GLACIER[1] is located on the north slopes between Mount Jackson and Blackfeet Mountain, members of the Livingston Range in the central part of Glacier National Park, Montana. The glacier rests upon limestone and dolomite of the pre-Cambrian Siyeh formation. The front of the glacier is now completely divorced from its immediate recessional moraine, which forms a striking and almost continuous ridge, interrupted where the main melt-water streams escape. Since its mapping in 1914 by the U. S. Geological Survey, the glacier has separated through ablation into two separate bodies of ice, a large one to the east and a smaller one to the west. A contoured map of the western ice body was com-

[1] W. C. Alden, "Glaciers of Glacier National Park," Department of the Interior, pp. 4–11, 1914.

pleted by the National Park Service, Belton, Mont., in 1939.

A conspicuous feature on the bed-rock exposed by retreat of the glacier is the incrustation of its surface with deposits of calcium carbonate. These carbonate deposits are almost pure white and therefore stand out in sharp contrast with the gray- and buff-colored dolomites. Close examination shows that the deposits are of lamellar structure and that they consist principally of calcium carbonate, in which tiny resistant rock fragments, predominantly of chert, are just visible megascopically. The deposits must once have completely covered the submarginal extent of the glacier floor, since they are regularly distributed over the entire area between the present ice front and the moraine. Minor advances of the glacier have eroded much of the material from existing smoothed surfaces, but it is retained in depression irregularities and in larger joint planes and fracture faces.

The writer infers that these calcium carbonate deposits have resulted from deposition by submarginal and marginal melt-water, which acted upon fine limestone rock flour resulting from ice abrasion. Calcium bicarbonate was produced, which was then taken into solution by the melt-water. A rise in temperature of the water as it issued from the glacier, loss of carbon dioxide to the air as the water passed over the irregular rock floor, changes in concentration of the solution and evaporation may have contributed to the precipitation and deposition of the calcium carbonate. Several specimens removed from the down-slope side of the rock surfaces showed distinct stalactitic structure. The individual lamellae average less than .05 inch in thickness, while the total thickness of the incrustation is usually not more than an inch. In a series of lamellae there is no consistent alternation of colors, although some lamellae are darker than others. It is probable that the lamellar structure is a result of seasonal fluctuations—most of the deposition taking place during the summer months and erosion or cessation of deposition during the winter months.

That such deposits persist only for a short period is indicated by the fact that none exists extra-morainally. Their presence in view of their short-lived occurrence should serve as evidence in support of postulations asserting very recent recession of glacier fronts. The phenomenon is, however, limited in its application to regions where the main erosive activities of the ice are directed against carbonate rocks.

Many instances of glacial striae cutting directly into the carbonate incrustations were observed at the Blackfeet Glacier site. These scorings, as noted above, indicate that even during the recent rapid retreat of the glacier front, the recession of the ice front was not progressive but was composed of alternate advances and retreats with retreat dominant.

Similar calcium carbonate incrustation deposits exist marginal to Sperry Glacier on the north slope of Gunsight Mountain, Glacier National Park. Like the occurrence at Blackfeet Glacier described above, these have not been heretofore referred to in the literature.

JOHN C. LUDLUM
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COMPOUND WORDS IN SCIENTIFIC NOMENCLATURE

LIKE a bolt out of the blue, the subject of English compound words has suddenly assumed an importance it should have assumed many decades ago; this fact is clearly evidenced by numerous letters appearing in recent issues of SCIENCE.[1] The diversity of opinion regarding compounding which was expressed in these letters is indicative of a chaotic situation which has been steadily developing over a long period of years.

The underlying causes of this development are: (1) a confusion of thought regarding the fundamental difference between a bona-fide compound word and a two-word phrase, frequently miscalled a "two-word form of compound"; (2) a wide-spread ignorance of the fact that a bona-fide compound may be a solid word as well as a hyphened word; and (3) a failure on the part of grammarians in general to give compounding and hyphenation the attention they deserve.

However, the situation is not at all hopeless; for the United States Government has taken the initiative in reducing the chaos to order. In 1933 it enunciated its first system of compounding, in the Style Manual of the Government Printing Office; and in 1937, its latest, most complete, and most rational system, in the Style Manual of the Department of State. The department system, in a slightly revised and augmented form possible of wider application, has recently been incorporated in a volume by the present writer entitled "Compounding in the English Language: A Comparative Review of Variant Authorities with a Rational System for General Use and a Comprehensive Alphabetic List of Compound Words."[2] It is the only system now generally recognized as authoritative. Scientists will be particularly interested in the following statement appearing therein: The compounding and hyphening of scientific and technical terms are governed by scientific and technical usage.

Scientific and technical terms constitute a category of compound words of such a special nature that no effort was made to take care of them in this system. But the system is just as adaptable to those terms as to any others, as will be seen from the following brief description.

The definition of a compound word stresses the need

[1] SCIENCE, 89: 413, May 5, 1939; 89: 582, June 23, 1939; 90: 155–157, Aug. 18, 1939.

[2] New York: The H. W. Wilson Company, 1939.

for physical union in compounding: A compound word is a union of two or more words which are joined together either with or without a hyphen. (For example: *light-year*; *radiotelegraphy*.)

Proper emphasis is placed upon the *two* problems always involved in compounding, which should not be but often are confused: (1) Is compounding (the physical union of words) necessary in any particular instance? (2) If so, should the compound word be hyphened or solid?

The first of these problems is answered under the headings "Words Preferably Not Compounded" and "Words Properly Compounded"; the second, under the headings "Hyphened Compounds" and "Solid Compounds."

The general principle governing compounding (the physical union of words) comprehends only the avoidance of ambiguity, whether that ambiguity is or is not due to syntactic incongruity.

The general principle governing the use of the hyphen in compounding comprehends both visual intelligibility and ephemeral usage.

There are only four main rules elaborating these general principles, each of which is followed by subrules setting forth specific categories of words to which it is applicable; moreover, all the rules harmonize completely with one another as well as with the general principles.

The first two main rules relate solely to compounding (the physical union of words) and may be jointly paraphrased as follows: If the meaning of two or more words used in regular order and in unconnected succession would be perfectly clear, compounding is unnecessary; if the meaning would not be perfectly clear, compounding is essential. (For example: *four o'clock*, two words, time; *four-o'clock*, compound word, a plant.)

Note that here there is an arbitrary joint meaning in the compounded words that is entirely lacking in the two-word phrase but that the word order is identical, the syntax being perfectly regular. It is irregular syntax, however, which most frequently makes compounding necessary; it is always irregular syntax that gives rise to the greatest difficulty. Therefore the subrules to the two main rules given above set out clearly the categories of word-sequences that are the most perplexing in compounding. Examples coming under these subrules are *source material, leaning tower, to wit, one half* (*of*) and *right of way* (separate words); *X-ray, one-half* (adv.), *to-do* (noun), *spinning-wheel* (implement), *know-it-all* (noun), *copyholder, airship,* and *shipbuilding* (hyphened and solid compounds).

The main rule governing the hyphenation of compound words is as follows: A hyphen is used to aid readability and denote temporary expediency.

All the following subrules indicate particular instances where the hyphen is essential for one of the purposes stated in the main rule. For example: *light-tight, loud-speaker* (radio), *four-o'clock* (plant), *ton-mile-day* and *old-age* (used adjectively) are all hyphened under some specific rule.

The main rule governing the solid form of compounds is very simple: Compounds for which a hyphen is not specifically provided are written as solid words. (For example: *hammerharden*.)

Other specific rules relate to "Prefixes, Suffixes and Combining Forms"; "Derivatives of Compounds," and "Elliptical Compounds." In this connection it should be stated emphatically that prefixes and suffixes form derivatives—not compound words; but since the hyphen is used in exceptional cases with all affixes (for example: *un-ionized*, hyphened to distinguish it from *unionized*, solid), any consideration of the subject of hyphenation would be incomplete unless such exceptional usage had been indicated. With regard to compound words, however, the reverse is true: there are no exceptions whatsoever to any rule for compounding in the entire system; and it is this invariable freedom from exceptions that makes it unique, workable and adaptable to all needs.

Lack of space precludes the giving of further details regarding this system; but sufficient has been said to show that it definitely provides for the non-compounding or compounding of every possible group of words used in juxtaposition. Its general acceptance by all scientific bodies for the compounding of purely scientific and technical words would prove helpful to them in straightening out their complicated problems.

ALICE MORTON BALL

WASHINGTON, D. C.

LEONARDO DA VINCI ON ISOSTASY

MODERN theory of isostasy originated with Dutton, who coined the term and based his theory unassailably on fundamental laws of statics.[1] The earlier elaborations of Pratt and of Airy had been challenged, and these should not be confused with Dutton's more general and less vulnerable presentation.

The recently translated Notebooks of Leonardo da Vinci reveal that the sixteenth century genius had anticipated Dutton vaguely, though Leonardo's insight into isostasy was wedded amazingly to the geocentric theory which later in life he abandoned. He clearly assigns the heights of mountains to their lesser density. To quote his words:

> That part of the surface of any heavy body will become more distant from the center of its gravity which becomes of greater lightness. The earth therefore, the element by which the rivers carry away the slopes of mountains and

[1] *Bull. Phil. Soc. Wash.*, 11: 51–64, 1889.

bear them to the sea, is the place from which such gravity is removed; it will make itself lighter and in consequence will make itself more remote from the center of gravity of the earth, that is from the center of gravity of the universe which is always concentric with the center of gravity of the earth. . . . The summits of the mountains in course of time rise continually.[2]

JOHN P. DELANEY

LOYOLA COLLEGE

JOSEPH LOUIS LAGRANGE

I AM preparing a study on the great mathematician, Joseph Louis Lagrange (1736–1813), and would welcome any information concerning MSS (letters from him or to him) in public or private libraries. I would gladly pay for photostatic copies of such MSS and the owner's courtesy would be fully acknowledged.

GEORGE SARTON

QUOTATIONS

INTERNATIONAL COOPERATION IN SCIENCE

ONE occasionally hears the statement that the trend of intellectual leadership is westward across the Atlantic. In proof of the assertion specific fields are mentioned, such as neuro-surgery, astronomy, dentistry and perhaps orthopedics, in which America has won pre-eminent standing. But this argument overlooks the many fields in which leadership, certainly until the war began, was still in Europe and the many others in which genius and stimulation are as potent on one side of the ocean as on the other. In physiology, for example, it would be difficult to determine whether the leadership lies in Europe or in the United States. The same is true of anatomy and pathology. In fields like pharmacology, tropical medicine, ophthalmology, legal medicine, social medicine and dermatology—to mention only a few—leadership is unquestionably still in Europe, or was in 1939. In mathematics, the English are indisputably pre-eminent in analytic number theory; the Russians are making important contributions in topology and probability, the French in algebra. America can not match the group of European scientists in the important fields of enzyme chemistry and the organic chemistry of natural products. Nowhere else in the world can one duplicate or even approach the coordinated and cooperating Scandinavian group which is focusing so many precise techniques of chemistry and physics on problems of biology.

If one is tempted to question the vitality of science in Europe, it is interesting to note that the most dramatic scientific development of the year 1939 originated there, *i.e.*, the splitting of the atom of the heavy element uranium and its transmutation into barium and other light elements. This realization of the old dream of the alchemists was based upon results obtained in 1934 by the Italian physicist Fermi; but the disintegration products of uranium were first directly observed in 1939, by Hahn and Strassmann of Berlin.

America needs to be humble about this question of intellectual leadership. In spite of the anxiety and insecurity abroad during these recent years, of the six Nobel prizes awarded in science in 1939, five went to Europe and one to the United States. In countless ways we are dependent upon Europe for stimulation and leadership in relation to many segments of our intellectual and cultural activity.

If because of war-exhaustion or chaos the universities and laboratories of Europe should be forced to suspend their fundamental activities for even half a decade, the consequences to the intellectual life of America would be immediate and disastrous. For scientific growth is almost invariably the result of cross-fertilization between laboratories and groups in widely separated parts of the world. Only rarely does one man or one group of men recite with clear, loud tones a whole important chapter, or even a whole important paragraph, in the epic of science. Much more often the start comes from some isolated and perhaps timid voice, making an inspired suggestion, raising a stimulating question. This first whisper echoes about the world of science, the reverberation from each laboratory purifying and strengthening the message, until presently the voice of science is decisive and authoritative. Thus, in the case of the breakdown of uranium during the past year, the early tentative questionings came from Rome; they were caught up at Berlin, were eagerly heard at Paris and Copenhagen and then spanned the Atlantic and were seized upon here so enthusiastically that literally within hours, rather than within days, the critical experiments had been checked and extended at Columbia University, at the Carnegie Institution of Washington and in Lawrence's laboratory at the University of California.

Similarly, the amazing development and application of sulfanilamide—that beneficent gift to mankind—has been the result of a collaboration in which flags and boundary lines have been non-existent. The first hint of it was discovered in Germany, oddly enough in connection with the commercial dye industry, and the drug was given the name prontosil. With this

[2] The Notebooks of Leonardo da Vinci, Edw. MacCurdy, Vol. 1, p. 344.

hint as a basis, in 1935 a German scientist—Dr. Gerhard Domagk—published the results of his experiments with mice under carefully controlled laboratory conditions, showing the extraordinary effect of prontosil on streptococcus. The Pasteur Institute in Paris then picked the matter up, and subjecting prontosil to organic analysis discovered that its activity was localized in one distinctive part of its molecular structure. This potent factor in prontosil, separated from the rest of the molecule, is what we now know as sulfanilamide. At this point Queen Charlotte's Hospital in London, with a grant from The Rockefeller Foundation, tried the drug on women suffering from streptococcal infection associated with puerperal or childbirth fever, immediately reducing the death rate from such infections by 25 per cent. The Johns Hopkins School of Medicine was the next institution to carry forward the experiments, and in the last three years research on this drug has been developed, with brilliant results, in laboratories and hospitals on both sides of the Atlantic.

Achievement in science, more often than not, is the result of the sustained thinking of many minds in many countries driving toward a common goal. The creative spirit of man can not successfully be localized or nationalized. Ideas are starved when they are fenced in behind frontiers. The fundamental unity of modern civilization is the unity of its intellectual life, and that life can not without disaster be broken up into separate parts. If, as a result of the present cataclysm on the other side of the Atlantic, Europe freezes into an Arctic night, we shall not easily keep the fires lit in the universities and laboratories of America.—*Raymond B. Fosdick in the Review of the Rockefeller Foundation for 1939.*

SOCIETIES AND MEETINGS

THE KANSAS ACADEMY OF SCIENCE

The seventy-second annual meeting of the Kansas Academy of Science was held from March 28 to 30 at the University of Wichita, Wichita, Kansas, with Dr. H. H. Hall, professor of biology, Kansas State Teachers College, Pittsburg, as president. Affiliated with the academy and meeting as a section, the Kansas Entomological Society held its sixteenth annual meeting, but the Weather-Crops Seminar held its meeting at Wichita last fall. The Kansas and Southern Nebraska chapter of the American Association of University Professors, the Kansas Section of the Mathematical Association of America and the Kansas Association of Teachers of Mathematics met in cooperation with the academy. The meetings are summarized in Table I.

The Junior Academy of Science, under the direction of an academy committee consisting of J. A. Brownlee, Edith Beach and J. R. Wells, had a program consisting of demonstrations from 13 Junior Academy groups out of the 28 clubs enrolled.

Special features for the general meetings were the lecture on Thursday evening on March 28, on "Meteorites" by Dr. H. H. Nininger, curator of meteorites, Colorado Museum of Natural History, Denver; the public lecture on Friday evening by Dr. E. C. Auchter, chief of the Bureau of Plant Industry, Washington, D. C., on the subject, "Plant Research and Human Welfare," and the banquet with Dean E. O. Deere, Bethany College, as toastmaster, who introduced the life and honorary members present and read letters of greeting from absent ones. President W. M. Jardine, of the University of Wichita, gave a short but forceful address of welcome in which "more research" and "more light" were said to be needed to solve the stubborn problems of the nation.

The academy decided to begin the publication of a series of handbooks of pocket size. The handbook committee has recommended "Winter Twigs," by Dr. F. C. Gates, professor of botany, Kansas State College of Agriculture and Applied Science, Manhattan, and editor of the "Transactions" of the academy, as the first of the series.

The committee on conservation and ecology recommended, followed by academy approval, that an un-

TABLE I

Section or group	Presiding chairmen	Number of papers on program	Persons attending meeting	Chairmen for 1940–1941
Biology Teachers	John Breukelman	7	60	A. N. Gentry
Botany	M. W. Mayberry	26	62	F. W. Albertson
Chemistry	Harold P. Brown	10	90	K. S. Bergstresser
Physics	A. B. Cardwell	16	48	S. Winston Cram
Psychology	W. H. Mikesell	15	55	Geo. Kelly
Zoology	A. B. Leonard	34	80	Robert Bugbee
Geology	A. C. Carpenter	20	45	Carl Barnhart
Phy. Science Teachers	Lawrence Oncley	6	25	Lawrence Oncley
Entomology	R. T. Cotton	28	45	R. L. Parker
Junior Acad. Com.	J. A. Brownlee	13	400	J. R. Wells
Weather-Crops Sem.		..	...	W. A. Cochel
Amer. Asn. Univ. Professors	Robert Conover	6	40	Robert Conover
Mathematical Asn. of America	Cecil B. Read	9	44	C. B. Price
Kans. Asn. of Teachers of Math.	Gilbert Ulmer	9	65	Mrs. Adelle Davis

usual area of sand dunes in the Arkansas River valley, south of Syracuse in Hamilton County, be made a state park for preservation as a natural area.

A new section—a College Students' Section—was added by request for next year with M. W. Allen, Coffeyville Junior College, as chairman.

The committee on research awards of the academy made grants for the year 1940–41 totaling $207.50 to the following persons: John Breukelman, Kansas State Teachers College, Emporia; Stuart Pady, Ottawa University, Ottawa; Lawrence Oncley, Southwestern College, Winfield; Dean R. Isaacs, Fort Hays Kansas State College, Hays; Allen C. Olsen, Kansas State College, Manhattan, and M. D. Wheatley, University of Kansas, Lawrence. The source of the funds was $32.50 from the Albert T. Reagan Memorial Endowment, $75.00 from the American Association for the Advancement of Science and $100.00 from the academy treasury.

Volume 42 of the "Transactions," which was a clothbound book of 517 pages, was distributed to the membership on February 23, 1940. There are approximately 600 persons, 28 Junior Academy groups and 9 libraries now on the academy membership roll. The deaths of two life members—Larry M. Peace and Joshua W. Beede and one annual member, F. H. Dickinson, were reported. Dr. Edward Weidlein and Dr. Charles E. Burt were elected life members.

The academy will meet at Manhattan next year and at Hays in 1942. The following officers were elected: *President,* E. O. Deere; *President-elect,* F. C. Gates; *Vice-president,* R. H. Wheeler; *Secretary,* Roger C. Smith; *Treasurer,* H. A. Zinszer; additional members to the Executive Council, W. H. Schoewe, John Breukelman and H. H. Hall; *Managing Editor,* W. J. Baumgartner; *Editorial Board,* Geo. Kelley and D. J. Ameel, the latter serving as academy librarian.

The excellent rooms, largely in recently constructed buildings, with their equipment and furnishing provided by the University of Wichita, contributed much to the success of the meeting.

Roger C. Smith,
Secretary

THE IOWA ACADEMY OF SCIENCE

The fifty-fourth annual meeting of the Iowa Academy of Science was held at Cornell College at Mount Vernon, Iowa, on April 19 and 20, with 258 members and visitors in registered attendance.

The presidential address, "Science and Progress," was presented by Dr. R. B. McClenon, professor of mathematics at Grinnell College. Other papers on the general program were "Chemical Transformations by Acetobacter," by Nandor Porges, of the United States Department of Agriculture and "Chemical Evidence of Alcoholic Intoxication," by Professor R. W. Getchell, of Iowa State Teachers College. The annual address, "Television," was presented by Dr. H. H. Sheldon, of the New York University and the American Institute of the City of New York.

Two symposia were high-lights in the Friday afternoon session. The first of these under the chairmanship of Dr. C. J. Lapp, of the physics department of the State University of Iowa, was entitled "Basic Factors in Achievement at the College Level." Dr. Martin F. Fritz, of Iowa State College, and Drs. James B. Stroud and John A. McGeoch, of the State University of Iowa, led the discussion. The second, on "Vitamins," was sponsored jointly by the Academy and the Iowa State Medical Society. The chairman was Dr. W. M. Hale, of the State University of Iowa, and Dr. Norman A. Clark, of the Iowa State College, and Drs. P. C. Jeans and K. M. Brinkhous, of the Medical School of the State University, presented papers on "Vitamins in Plants," "Vitamin D in Human Nutrition" and "Vitamin K," respectively.

In addition to these symposia, the Academy met in eight sections for the presentation of 110 papers of special interest, and the Junior Academy of Science of Iowa met with the Academy. Dr. E. J. Cable and Dr. R. L. Abbott, of Iowa State Teachers College, and Dr. Nellie Naylor, of the Iowa State College, presented talks on their programs.

The following officers and section chairmen were elected for the next meeting which will be held at Simpson College, Indianola, Iowa:

President, Charles Carter, Parsons College; *vice-president,* Roy A. Nelson, Cornell College; *secretary-treasurer,* J. C. Gilman, Iowa State College; *editor,* Mrs. F. W. Nichols, Ames; *botany and bacteriology,* J. E. Sass, Iowa State College; *chemistry, general and physical,* Jacob Cornog, State University of Iowa; *chemistry, organic and biological,* J. B. Culbertson, Cornell College; *geology,* Louise Fillman, Simpson College; *mathematics,* J. Fred Robertson, Iowa State College; *physics,* Robert G. Wilson, Dubuque University; *psychology,* Paul C. Greene, Coe College; *science teaching,* R. M. Getchell, Iowa State Teachers College; *zoology,* F. G. Brooks, Cornell College. Cornelius Gouwens, Iowa State College, and H. E. Jaques of Iowa Wesleyan College were re-elected to the executive committee.

Joseph C. Gilman

Iowa State College

THE VIRGINIA ACADEMY OF SCIENCE

The eighteenth annual meeting of the Virginia Academy of Science was held at the Virginia Military Institute on May 2, 3 and 4 with a registration of 426. One hundred and eighty-three papers were read before the eight sections.

There was a Symposium on Jaundice in the Medical Section, and the Sections of Biology and Geology held a combined meeting to hear Dr. W. H. Camp, of the

New York Botanical Garden, speak on "Continental Displacement." Dr. Camp also gave the Friday night address on "A Winter in Oaxaca."

The Academy Prize of $50 was awarded to Walton C. Gregory for a paper entitled, "Experimental and Phylogenetic Studies in Cytology," and the Jefferson Prize of $50 was awarded to J. H. Yoe and L. G. Overholser for a paper entitled, "The Application of a New Class of Organic Reagent to the Detection and Determination of Palladium." This paper is now eligible to compete with four other papers awarded similar prizes by the Academies of Science of North Carolina, South Carolina, Georgia and Florida—the winner to be awarded a gold medal.

Officers elected for the coming year are: W. F. Rudd, *president;* E. C. L. Miller, *secretary-treasurer;* S. S. Negus, *assistant secretary-treasurer,* and George H. Jeffers, *president-elect.*

The new officers of sections are as follows:

Astronomy, Mathematics and Physics: Chairman, F. B. Haynes, Virginia Polytechnic Institute; *Secretary,* Isabel Boggs, Randolph-Macon Woman's College.

Biology: Chairman, E. DeWitt Miller, University of Virginia; *Vice-Chairman,* Lena Artz, Arlington; *Secretary,* R. F. Smart, University of Richmond.

Chemistry: Chairman, W. G. Guy, College of William and Mary; *Secretary,* W. O. Swan, Virginia Military Institute.

Education: Chairman, Paul G. Hook, Clifton Forge; *Secretary,* E. B. Broadwater, Salem.

Engineering: Chairman, D. H. Pletta, Virginia Polytechnic Institute; *Secretary,* Paul S. Dear, Virginia Polytechnic Institute.

Geology: Chairman, E. C. H. Lammers, Washington and Lee University; *Vice-Chairman,* R. S. Edmundson, University of Virginia; *Secretary,* William M. McGill, University of Virginia.

Medicine: Chairman, R. J. Main, Medical College of Virginia; *Secretary,* Guy W. Horsley, Richmond.

Psychology: Chairman, W. M. Hinton, Washington and Lee University; *Secretary,* Evelyn Raskin, Randolph-Macon Woman's College.

Saturday afternoon, eleven sponsors of high-school science clubs and fifty members of their clubs met and took preliminary steps which it is hoped will eventuate in the organization of a Junior Academy of Science.

The meeting next year will be held at the Medical College of Virginia.

E. C. L. MILLER,
Secretary

REPORTS

THE REPORT ON BIOLOGICAL ABSTRACTS FOR 1939

BIOLOGICAL ABSTRACTS is a non-profit, service organization run for the benefit of biologists and other interested persons. Consequently, the Board of Trustees is making a report on *Biological Abstracts* at this time. The financial statement given below is a summary of the picture for 1939 and indicates a slight decrease in reserves with an estimated net surplus of $12,000.00. It is apparent that a portion of this will have to be utilized during 1940 to make up for the anticipated decrease in income due to the European war.

Biological Abstracts entered 1939 with cash of $28,518.32. Income for the last volume (Vol. 13—1939) was derived as follows: Subscriptions, $38,194.21; advertising, $1,072.12; contributions of one sort or another from these societies—American Society of Zoologists, Society of American Bacteriologists, American Society of Naturalists, Poultry Science Association, American Phytopathological Society; Ecological Society of America, Botanical Society of America, Union of American Biological Societies—totaled $3,066.00; interest, postage, and miscellaneous, $586.06; this gives a total income from Volume 13 of $42,918.39. From this must be deducted salaries of $17,384.13 and printing and office overhead of $24,814.89, which leaves a balance of $719.37. During 1939 the Back Volume Fund (*i.e.,* the reserve fund from which the indices in arrears must be paid for, etc.) was credited with a total income for the year of $16,033.16. This income was derived from the sale of back volumes—$3,409.96—and the balance from societies, advertising and subscriptions to the previous volume (Volume 12). Expenses in connection with printing Volume 12 Index, extra editorial expense on the indices of Volumes 11 and 12 and the general Back Volume Fund expenses of $4,855.28 leave a balance of $852.27. Thus the cash at the end of 1939 stood at $23,979.60. From this must be deducted an estimated $14,380.97 for the printing, etc. of the Volume 11 Index and to pay the balances due on Volume 13, leaving an estimated net surplus on December 31, 1939, of $9,598.63 cash and $2,673.54 accounts receivable.[1]

During 1939 the coverage of journals increased from 895 in March to nearly 1,175 by December 31. A total of 18,108 abstracts were printed in 1939, which represents an increase of almost 11 per cent. over the preceding year. Due largely to the effective financial

[1] In storage there are a number of complete sets of Volumes 1–13 (1926–39). These have considerable value as shown by previous sales during 1938 and 1939 which amounted to $3,349.00 and $3,011.00, respectively.

and editorial assistance rendered by the Society of American Bacteriologists, the number of abstracts in Section C increased from 2,670 in 1938 to 3,657 in 1939. This represents an increase of almost 36 per cent.

All this was possible largely through two factors. In the first place, the ever-increasing efficiency of the editorial office played an important part. Here there was an increase of only one regular member and five temporary persons. In the next place success is due to the efforts of those able and generous collaborators, the section editors, who have contributed their valuable time and knowledge to the service. Eight new section editors were added to the staff during 1939.

One of the aims of *Biological Abstracts* has been to strive to maintain prompt publication of abstracts and indices. In October, 1936, only 24 per cent. of the abstracts of that number were from the current year's publications; in October, 1939, 82 per cent. of all abstracts were from papers published in 1939. The monthly issues are now on a regular schedule. The index to Volume 12 (1938) appeared within seven months and the last index in arrears (Vol. 11) appeared before the close of 1939. It is the hope and determination of all to better the Volume 12 record, if possible, with the Volume 13 Index.

It is interesting and significant that the number of paid subscriptions to *Biological Abstracts* increased from 1,660 for 1938 to 2,654 for 1939. This latter figure may be subdivided as follows:

Complete volume.	U. S.	647
" "	Foreign	632
Section	A	338
"	B	198
"	C	387
"	D	363
"	E	89
Grand total		2,654

In this connection it should be pointed out that the income from subscriptions in 1939 was not alone sufficient to meet all the budgetary demands. If it were not for the support of various biological societies and income from advertising and the sale of back volumes, the financial statement would not appear to be so satisfactory. It should be clear to all that *more subscriptions are needed.* Development of the service giving further increases in coverage is dependent solely upon income. As more biologists come to recognize the value of this journal in economizing time and broadening their scientific range, and as more libraries subscribe, increased income will permit an expanded service.

BOARD OF TRUSTEES, BIOLOGICAL ABSTRACTS

SPECIAL ARTICLES

THE SYNTHESIS OF GLYCOCYAMINE IN RAT KIDNEY AND A MECHANISM OF CREATINE SYNTHESIS IN VIVO

GLYCOCYAMINE (guanidino-acetic acid) is converted into creatine (N-methyl guanidino-acetic acid) by surviving liver slices. The methylating agent may be methionine or a derivative of methionine.[1]

Liver slices of all animals investigated are capable of effecting this methylation[2] at a rate sufficiently fast to make good the total loss as urinary creatinine. It is highly improbable that this property of liver is a fortuitous coincidence of no physiological significance; the more probable inference is that methylation of glycocyamine is one of the important physiological mechanisms of creatine synthesis.

This conclusion was strengthened by the finding of Bloch and Schoenheimer, who, using N_{15} as a tracer, found that in the living animal (rat) glycocyamine is readily converted to creatine.[3]

The origin of glycocyamine has thus acquired an augmented physiological significance. We have found that rat kidney slices form glycocyamine from arginine and glycine with great rapidity. That the substance formed is glycocyamine was proven by the following tests: conversion to glycocyamidine by heating in acid solution; it was not digested by the NC bacteria of Dubos and Miller[4] under conditions in which creatine and creatinine are completely digested; a very strongly positive Sakaguchi test was obtained after all the arginine was removed by exhaustive adsorption on permutit; preparation of the characteristic glycocyamine acetate; isolation and its identity proven by elementary analysis.

With surviving rat kidney slices the rate of formation of glycocyamine from arginine and glycine is as rapid as urea formation by rat liver slices from ammonia and ornithine. This interaction of arginine and glycine is also catalyzed by thoroughly macerated kidney tissue suspended in a phosphate buffer at pH 7.4.

Surviving rat liver slices are incapable of carrying out this reaction.

Arginine and sarcosine also yield glycocyamine (not

[1] H. Borsook and J. W. Dubnoff, *Jour. Biol. Chem.*, 132: 559, 1940.

[2] *Ibid., Jour. Biol. Chem.*, in press.

[3] K. Bloch and R. Schoenheimer, *Jour. Biol. Chem.*, 133: 633, 1940.

[4] B. F. Miller and R. Dubos, *Proc. Soc. Exp. Biol. and Med.*, 35: 335, 1936; R. Dubos and B. F. Miller, *Jour. Biol. Chem.*, 121: 429, 1937.

creatine); this reaction is slower than the interaction of arginine and glycine. These two findings indicate that the sarcosine is demethylated first. This also is in accord with the findings of Bloch and Schoenheimer with N_{15}.

Our findings account for the other observations of Bloch and Schoenheimer that when ammonia containing N_{15} is fed the isotope is found later in the amidine $\left(-\mathrm{C}\begin{matrix}\diagup \mathrm{NH_2}\\ \diagdown\!\!\diagdown \mathrm{NH}\end{matrix}\right)$ nitrogen of creatine. When glycine containing N_{15} is administered the isotope is found in creatine in the sarcosine nitrogen.

The formation of glycocyamine from arginine and glycine is a new biochemical reaction which may be called "transamidination." The discovery of this reaction in the kidney (the possibility of its occurring in other tissues is now being investigated) provides direct proof that arginine and glycine are precursors of creatine.

We have found previously that glycocyamine is not methylated in the kidney; this occurs in the liver.[2] Glycocyamine is formed in the kidney. Both kidney and liver therefore participate in the formation of creatine.

HENRY BORSOOK
JACOB W. DUBNOFF

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NUTRITION AS A FACTOR IN THE DEVELOPMENT OF CONSTITUTIONAL BARRIERS TO INVOLVEMENT OF THE NERVOUS SYSTEM BY CERTAIN VIRUSES

RECENT investigations[1,2] have demonstrated that as animals grow older they may develop resistance to involvement of the nervous system by certain viruses not because of immunity acquired as a result of exposure to infection, nor because of a maturation affecting the whole animal or its entire nervous system, but rather as a result of changes in certain tissues or structures which those viruses must pass before they can give rise to paralysis or encephalitis. The purpose of the present communication is to report some preliminary experiments which indicate that the nutrition of the growing animal or even that of the mother during the nursing period can exert an influence on the development of those tissue changes which serve as barriers to the invasion of the nervous system by certain viruses.

The effect of intramuscular injection of vesicular stomatitis virus in mice was selected as the indicator of at least one type of such constitutional resistance because (1) under standard conditions mice of different ages react with great regularity, and (2) the pathogenesis of the disease and spread of the virus in both young and old has already been investigated in considerable detail. Preliminary tests on the albino mice used in the present experiments were in agreement with previous observations on another stock of albino mice in that it was found that at 2 weeks of age almost 100 per cent. develop a fatal ascending paralysis, at 3 weeks 80 to 90 per cent., and at 4 weeks only 10 to 20 per cent.; at 5 weeks of age the incidence of paralysis is 5 per cent. or less, and beyond the 6th week, resistance is close to 100 per cent. Previous studies have indicated that some change in the muscle cells or nerve endings or both of the maturing animals is responsible for the resistance, since the older mice remain susceptible to intracerebral or intraneural injection of the virus.

Because the change from 100 per cent. susceptibility to approximately 100 per cent. resistance occurs between the 14th and 35th days of life, and because mice continue to suckle for about 28 days, although during the last 7 or 8 days they also eat the maternal diet, two different types of feeding experiments were designed to test the role of nutrition. In one set of experiments the mothers were maintained on standard "adequate" diets throughout pregnancy and for 2 days after delivery, when they were given the various diets indicated in Table I; the offspring remained with their mothers for at least 28 days and then continued on the respective diets until the termination of the tests. In the second set of experiments, mice, suckling mothers which were receiving standard adequate diets, were weaned at 14 days; different groups made up of approximately equal numbers of siblings were given the various diets indicated in Table II. Different groups of mice were tested for resistance at 4, 5 and 6 weeks of age by an inoculation into the calf muscles of 0.2 cc of a 10 per cent. suspension of the brains of mice succumbing after intracerebral injection of the N. J. strain of vesicular stomatitis virus; this dose contains 1 to 10 million minimal cerebral lethal doses of virus. The potency of the virus was checked in each test by intracerebral titration.

The results presented in Tables I and II can be regarded only as indicating a certain trend, since the actual percentages of resistant animals in the various groups will probably change when the work is extended on larger numbers of mice. The following indications, however, are apparent:

I. When the maternal diet during the nursing period consisted of:

(a) *An artificial, purified stock diet adequately supplemented by the various vitamins*—the offspring appeared to develop their resistance normally, *i.e.*, at the same rate as when the diet consisted of a mixture of many natural foods.

[1] A. B. Sabin and P. K. Olitsky, *Jour. Exp. Med.*, 66: 15, 1937; *ibid.*, 66: 35, 1937; *ibid.*, 67: 201, 1938; *ibid.*, 67: 229, 1938; *Proc. Soc. Exp. Biol. and Med.*, 38: 595, 1938; *ibid.*, 38: 597, 1938.

[2] A. B. Sabin, SCIENCE, 91: 84, 1940.

TABLE I

INFLUENCE OF MATERNAL DIET DURING NURSING PERIOD ON DEVELOPMENT OF RESISTANCE IN OFFSPRING (V. S. VIRUS INTRAMUSCULARLY)

Diet	Age of mice								
	4 weeks			5 weeks			6 weeks		
	Per cent. resistant	No. tested	Av. wt.	Per cent. resistant	No. tested	Av. wt.	Per cent. resistant	No. tested	Av. wt.
			gm			gm			gm
"M" diet or "M" diet + milk + yeast + CLO	*82*	75	13.4	*94*	18	15.0	..	..	...
CSLS + yeast + CLO + WGO	*73*	15	9.7	*93*	14	12.9	*100*	12	12.0
" + " + " (deficient in E)	*46*	15	9.5	*80*	15	13.6	*100*	10	15.4
" + RPC + " + WGO (deficient in B complex except in B_1)	*0*	13	5.3	*90*	10	7.5	*64*	11	8.1
CSLS + autoclaved yeast + CLO + WGO (deficient in heat-labile B)	*0*	8	4.3	No survivors on diet					

"M" diet = dry powder consisting of yellow corn meal (45 per cent.), ground wheat (20 per cent.), ground oats (12 per cent.), alfalfa meal, 2 per cent.), bone meal (2 per cent.), dried skimmed milk (8 per cent.), tankage (4 per cent.), sodium chloride (2 per cent.), calcium carbonate (1 per cent.), and meat scraps (4 per cent.).
CSLS = vitamin-free casein (22 per cent.) + corn starch (54 per cent.) + lard (20 per cent.) + McCollum's salt mixture (4 per cent.).
CLO = cod liver oil (4 per cent.); WGO = wheat germ oil (0.5 per cent.); RPC = rice polishings concentrate (6 per cent.). Yeast = brewers' yeast (8 per cent.). Av. wt. = average weight.

(b) *The supplemented artificial diet deficient in wheat germ oil (vitamin E)*—development of resistance was retarded in some of the offspring, but at 6 weeks all were resistant. We had an opportunity to test 25 mice whose mothers had been on an E deficient diet for a still longer period, *i.e.*, since one to two weeks before delivery, and they were all resistant at 6 weeks of age.[3]

(c) *The supplemented artificial diet deficient in all the components of B complex except B_1*—all of the offspring inoculated at 4 weeks of age developed paralysis, and while an appreciable number became resistant in subsequent weeks it will be necessary to test larger numbers of mice before one can evaluate the ultimate effect of this deficiency.

(d) *The supplemented artificial diet, differing from that used in (a) only in the autoclaving of the yeast (16 lbs. for 10 hours)*—there was the greatest interference with normal development. Largely because of cannibalism practiced by the mothers and the more aggressive offspring as they grew up, only 8 mice of a group of 54 survived for the test at 4 weeks of age. All of the survivors succumbed to inoculation of the virus, but in 6 of them the disease was different from that usually observed in that they died very shortly after invasion of the spinal cord by the virus (proved by subinoculation) without showing paralysis.

II. When mice, suckling mothers which were on standard adequate diets, were weaned at 14 days of age and continued on:

(a) *A diet consisting of a mixture of many natural foods ("M" diet) supplemented with fresh whole milk (37 per cent.), yeast (6 per cent.), and cod liver oil (2 per cent.)*—there was both a good gain in weight and normal development of resistance.

(b) *The same mixture of natural foods, fresh milk and added vitamins, but only in amounts sufficient to maintain their original weight*—the mice increased in size, although not in weight, but failed to develop resistance to the spread of the virus, for even at 5 weeks of age 92 per cent. developed paralysis whereas all their litter mates which received the same diet in adequate amounts remained well.

(c) *The supplemented artificial diet*—while not quite as many mice were resistant at 4 weeks as under standard

[3] We are grateful to Dr. Karl E. Mason, of the Vanderbilt University School of Medicine, for supplying us with these mice.

TABLE II

DEVELOPMENT OF RESISTANCE IN PREMATURELY WEANED MICE RECEIVING QUANTITATIVELY OF QUALITATIVELY INADEQUATE DIETS (V. S. VIRUS INTRAMUSCULARLY)

Diet	Age of mice								
	4 weeks			5 weeks			6 weeks		
	Per cent. resistant	No. tested	Av. wt.	Per cent. resistant	No. tested	Av. wt.	Per cent. resistant	No. tested	Av. wt.
			gm			gm			gm
"M" diet + whole milk + yeast + CLO, ad lib.	*78*	9	12.4	*100*	19	16.8	..	..	...
"M" diet + whole milk + yeast + CLO, q.s. maintain wt.	*13*	23	6.6	*8*	13	6.9	..	..	...
CSLS + CLO + WGO + yeast	*63*	16	12.3	*100*	12	13.2	*91*	11	14.8
" + " + " + RPC (deficient in B complex except B_1)	*67*	15	8.2	*67*	18	8.8	*89*	9	10.7
CSLS + CLO + yeast (deficient in E)	*20*	15	9.7	*100*	10	14.3	(*33*)	6	13.8
" + " + WGO + autoclaved yeast (deficient in heat-labile B)	*20*	15	8.6	*33*	15	6.7	*67*	9	10.7

Mice suckling mothers on standard diet, weaned at 14 days of age.
Abbreviations—same as in Table I.

conditions, those tested at 5 and 6 weeks of age were up to the optimum level.

(d) *The supplemented artificial diet deficient in all the components of the B complex except B_1*—there was a retardation in many mice, in that only 67 per cent. were resistant at 5 weeks as compared with 100 per cent. in the control group.

(e) *The supplemented artificial diet deficient in wheat germ oil (vitamin E)*—only 20 per cent. were resistant at 4 weeks of age. The 33 per cent. resistance observed at 6 weeks can not be regarded as significant until more mice have been tested.

(f) *The supplemented artificial diet deficient in the heat-labile components of the B complex*—the two weeks of nursing on properly fed mothers protected these mice sufficiently to prevent cannibalism and loss of life, but associated with increasing signs of vitamin B_1 deficiency, there was marked retardation in the development of resistance.

It is thus apparent that the presence or absence of certain factors either in the maternal diet during the nursing period or in the diet of actively growing young mice can promote, retard or inhibit the development of at least one type of constitutional barrier to involvement of the nervous system by a neurotropic virus. Not until the effect of adding the synthetic vitamins B_1, riboflavin or E to the respective, deficient diets has been studied will it be possible to state whether or not they, or other substances, are the factors which play a role in the development of this resistance. It should also be noted here that while inadequate nutrition could prevent or retard the appearance of this resistance in growing mice, it has not yet proved possible to break it down by the same means once it has been acquired by full-grown animals, even after they have developed signs of advanced vitamin B_1, E or riboflavin deficiencies.

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EFFECT OF ESTROGENS AND ANDROGENS ALONE AND IN COMBINATION WITH CHORIONIC GONADOTROPIN ON THE OVARY OF THE HYPOPHYSECTOMIZED RAT[1]

IN 1928 Aschheim and Zondek[2] announced their discovery of a pituitary-like gonadotropin in the urine of the pregnant woman. Administered to immature female rats or mice, it caused follicular growth and luteinization in the ovaries. Subsequent studies showed that a typical A–Z response could not be secured in the hypophysectomized animal.[3,4,5]

Of the several theories advanced in explanation of the lack of effect of chorionic gonadotropin in the hypophysectomized animal, the one most generally accepted is that the pituitary of the normal animal contributes a "complementary" factor essential for the production of large follicles and corpora lutea. The secretion of this factor is believed to be mediated through the ovary, but the nature of this principle has not been definitely identified.

In connection with experiments designed to test the effects of estrogens and androgens administered alone and in combination with gonadotropins on the gonads of the normal animal, it was of interest to extend similar studies to the hypophysectomized animal. It was thought that the use of the hypophysectomized animal would obviate any modifying influences that would necessarily be introduced by the intact animal's pituitary. What follows relates to the results secured in the hypophysectomized series treated with diethylstilboestrol, estradiol dipropionate and testosterone propionate alone and in combination with chorionic gonadotropin.

The experimental material included 44 rats, 21 to 23 days old at the time of hypophysectomy. The crystalline hormones were compressed into pellets and inserted under the skin.[6] The gonadotropin was Antuitrin "S," labeled to contain 500 R.U. in each cc. Nineteen of the treated animals were allowed a seven-day regression period prior to implantation of the pellets. In twenty animals the pellets were embedded

TABLE 1

EFFECT OF DIETHYLSTILBOESTROL, ESTRADIOL DIPROPIONATE, TESTOSTERONE PROPIONATE GIVEN ALONE AND IN COMBINATION WITH CHORIONIC GONADOTROPIN ON OVARIAN GROWTH IN HYPOPHYSECTOMIZED IMMATURE RAT*

Treatment	Number of animals	Average weight of ovaries—mg
None	5	7
Diethylstilboestrol	8	28
Estradiol dipropionate	5	13
Testosterone propionate	3	8
Antuitrin "S"	9	14
Diethylstilboestrol and Antuitrin "S"	8	103
Estradiol propionate and Antuitrin "S"	3	21
Testosterone propionate and Antuitrin "S"	3	8

* The crystalline hormones were compressed into pellets and inserted under the skin. The average daily absorption (as determined by weighing the pellets at the time of implantation and on removal at necropsy) of diethylstilboestrol varied from 130 to 170 micrograms, and 40 to 63 micrograms for estradiol dipropionate. The total dose of chorionic gonadotropin was 75 R.U., distributed over three days with necropsy 96 hours after the first injection.

1 Supported by the Christine Breon Fund for Medical Research.

2 S. Aschheim and B. Zondek, *Klin. Wchnschr.*, 7: 8, 1928.

3 F. L. Reichert, *et al.*, *Proc. Soc. Exp. Biol. and Med.*, 28: 843, 1931.

4 Y. Noguchi, *Jap. Jour. Med. Sci. and Pharm.*, 5: 104, 1931.

5 J. B. Collip, *et al.*, *Nature*, 131: 56, 1933.

6 The author is grateful to Dr. G. Biskind, Mount Zion Hospital, San Francisco, who generously prepared the sterol pellets.

in the subcutaneous tissues in the region of the neck at the time of hypophysectomy; the remaining five served as controls. Three to seven days subsequently, the animals were divided into groups and treated as indicated in Table 1.

It will be noted that both diethylstilboestrol and estradiol dipropionate treatment led to considerable ovarian enlargement. This occurred even after the ovaries had undergone considerable involution following hypophysectomy. The average ovarian weight was 28 mg following diethylstilboestrol treatment and 13 mg following estradiol dipropionate, compared with 7 mg in the untreated hypophysectomized controls.[7] Testosterone propionate, although shown to be slightly estrogenic in both normal and hypophysectomized rats,[8, 9] was without effect.

The most striking difference in ovarian growth, however, occurred in the animals implanted with diethylstilboestrol pellets and subsequently injected with chorionic gonadotropin. The average ovarian weight of the animals receiving the combined treatment was 103 mg as compared with 14 mg with chorionic gonadotropin alone. Estradiol dipropionate, although markedly estrogenic and prolonged in its action,[10] yielded ovaries weighing but 21 mg, a value not significantly greater than that secured with the sterol alone. In this respect, testosterone propionate in combination with chorionic gonadotropin also proved ineffective.

Exceedingly interesting were the microscopic findings resulting from the different types of treatment. The ovaries of the diethylstilboestrol treated animals consisted of medium-sized follicles packed tightly together and markedly reduced interstitial tissue. Estradiol dipropionate, though causing some ovarian stimulation, was not as effective as diethylstilboestrol. The ovaries of the testosterone propionate treated animals showed no significant changes.

The most pronounced effect was secured in the animals implanted with diethylstilboestrol and subsequently injected with chorionic gonadotropin. The follicles were enlarged, many corpora lutea were present, and in two instances hemorrhagic follicles were also found. Similar treatment with estradiol dipropionate and testosterone propionate in combination with chorionic gonadotropin failed to give the ovarian development secured with diethylstilboestrol.

A partial explanation for the discrepancies in the results secured with diethylstilboestrol and estradiol dipropionate in combination with chorionic gonadotropin may perhaps be found in the amount of material absorbed. The average daily absorption for diethylstilboestrol (as determined by weighing the pellets at the time of implantation and on removal at necropsy) varied from 130 to 170 micrograms as compared with 40 to 63 micrograms for estradiol dipropionate. This suggests that the estrogen level necessary to enhance the effect of chorionic gonadotropin must be relatively high. The difference in behavior of the two sterols is now under further investigation.

The significance of the experiments just described and their broader application to hypophyseal-ovarian physiology will be discussed elsewhere.

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SCIENTIFIC APPARATUS AND LABORATORY METHODS

MICROFILM WITH THE 35-MILLIMETER CANDID CAMERA

The use of microfilm is becoming of increasing interest as is evidenced by the number of libraries offering microfilm service and the fact that at least three journals are devoted mainly to this subject. Many advantages of microfilm have been summarized by Seidell.[1] The purpose of the present note is to call the attention of scientists to the ease with which an inexpensive 35-mm camera may be used to make their own microfilm for short runs of a few pages. Such film may be read without undue eyestrain, using the Seidell hand reader costing $1.50. The price ranges of microfilm cameras and projection readers have been reported[2] as varying from $50.00 to $5,750 and from twenty to several hundred dollars, respectively. English,[3] in *American Photography*, has given details for building a complete outfit including projection reader for about $50.00.

It has been stated[4] that photostats are more useful for short runs of a few pages and microfilm is better adapted for long runs. This is undoubtedly true on the basis of cost where the service charge is an important part of the total. Nevertheless, microfilm for short articles is of great potential use to any one who has a 35-mm camera available. By means of such a camera and a stand made from laboratory

[7] P. C. Williams, *Nature*, 14: 388, 1940, also reports ovarian enlargement in hypophysectomized rats implanted with diethylstilboestrol.

[8] A. Butenandt and H. Kudszus, *Hopper-Seyl. Z.*, 237: 75, 1935.

[9] A. S. Parkes and S. Zuckerman, *Jour. Physiol.*, 93: 16P, 1938.

[10] K. Miescher, *Biochem. Jour.*, 32: 725, 1938.

[1] A. Seidell, Science, 89: 32–4, 1939.

[2] V. D. Tate, *Jour. Documentary Reproduction*, 1, No. 3, Part 2, 6 and 36, 1938.

[3] F. L. English, *Amer. Photography*, 32: 825–8, 1938.

[4] H. H. Fussler, *Jour. Documentary Reproduction*, 2, No. 1, 3–4, 1939.

materials, a scientist may make his own microfilm and greatly increase his library at a cost of less than one cent per exposure.

It is not intended that such individually-made film should compete with that produced by bibliofilm service on long runs where the service charge is negligible in comparison with the total cost. However, there are numerous short articles, tables, diagrams, bibliographies, graduate theses, etc., which are desirable to have on file but which can not be obtained as reprints. This is particularly true of foreign publications and those trade journals which do not furnish reprints, and of detailed tables on analytical procedures from bound volumes, any of which may be borrowed for a short time from a library. For this class of work, an ordinary 35-mm candid camera, ranging in price from ten dollars up, when provided with a copying lens and cable release, is quite satisfactory. A copying lens costs a dollar and a cable release about 75 cents. Film developing can be done in an inexpensive daylight developing tank. Commercial photographers charge approximately 10 cents per roll (36 to 42 frames). Ordinary film can be obtained in 25-foot rolls at less than one cent per frame. (One-hundred-foot rolls—about 700 frames—cost about $3.00.) This film is suitable for reading with a hand reader. However, if the film is to be used in projection reading machines where it will be exposed to heat, it will be necessary to use safety-base film.

Apparatus: In the following work an Argus Model C camera, fitted with a portrait lens and a cable release, was used. The camera, with the lens pointing downward through a two-inch hole, was mounted on a specially prepared board. The camera was held in place by strips of wood around three edges; thinner strips held the face of the camera up from the board to give clearance for the shutter lever. The camera was held firmly but could be easily removed for other uses. This wooden frame was wired securely to a 6-inch ring and a large ring stand was used as a support. With the ring used, the camera lens was 6.5 in. from the rod, and this proved satisfactory for ordinary books and journals. If larger objects, such as a newspaper, were to be photographed, an extensible support would be necessary. The field covered was 8.75 in. by 13.25 in. at a height of 20 in. and 12.5 in. by 19 in. at a height of 28 in. It is helpful to have the upper and lower part of the ring stand rod marked in inches so that the height may be adjusted. Two T-shaped rods were used with ring stand clamps to hold down the edges of the journal being photographed. It is well to set the stand on a black cloth to avoid glare from polished table tops. After adjustment, it is advisable to steady the support by a brace from a second ring stand to reduce the possibility of vibration. Either strong indirect daylight or artificial light may be used for illumination.

Operation: The article to be copied was centered in position and the pages held level with the T-shaped rods. The name of the journal, date, etc., if not appearing in the article, was printed on a card and laid on the margin of the article. (This card may be used to cover portions of other articles appearing on the same page. If the microfilm is to be filed by number or subject, this data may be added and inch figures, after photographing, may be easily read without optical aid for ease in filing.) The camera support was placed at the proper height and the camera put in position. A cable release was used to avoid vibration, and the exposure was made. Time and diaphragm opening will vary according to the lighting, and a little experimentation will fix the optimum conditions. With daylight, in a well-lighted room and with fast film (Scheiner No. 23), equally good results were obtained with an exposure of 10 seconds at f:11 and 0.2 second at f:3.5. The f:11 diaphragm opening allows considerable latitude in focusing, which is helpful if journals of different thicknesses are used, since the camera height need not be changed. It was not necessary to remove the camera between exposures, the shutter being cocked by inserting the eraser end of a pencil between the support and the camera.

Discussion: The method described has been found to be very satisfactory for the making of short runs of microfilm. The films are conveniently stored in numbered glassine or kraft paper envelopes and correspondingly numbered cards are kept in the regular filing system. (Dice[5] and Brown and Austin[6] have described filing systems for microfilm.) Films should not be developed to high density and contrast because the softer grey background is easier on the eyes than a dense black. For diagrams with tiny numerals, it is desirable to take close-ups particularly when the film is to be examined with a hand reader.

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[5] L. R. Dice, SCIENCE, 89: 39–40, 1939.

[6] H. P. Brown and J. A. Austin, SCIENCE, 90: 573–574, 1939.

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